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THESIS

IMPROVING MILITARY CHANGE DETECTION SKILLS IN A VIRTUAL ENVIRONMENT: THE EFFECTS OF TIME, THREAT LEVEL, AND TUTORIALS

by

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September 2011

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13. ABSTRACT (maximum 200 words)

The first one hundred days of combat are the most dangerous time for a soldier due to uncertainty and unfamiliarity with his area of operations. Developing a desktop virtual trainer for change detection could reduce the threat to soldiers by improving their ability to detect signals among the cluttered, noisy neighborhoods of the current operational environment. Building upon previous change detection and signal detection work, this thesis explores the use of Army Virtual Battlespace 2™ as a prototype-training tool for change detection. Leveraging an Army-owned distributable trainer would potentially benefit soldiers prior to deployment. This research team conducted an experiment that tested fifteen participants over four weeks. Each participant explored the virtual environment twelve times. Researchers analyzed correct detections, false alarms, user confidence, threat levels, and tutorial group assignment. This first attempt at developing a military-oriented virtual trainer resulted in statistically significant improvement in detection percentages, user confidence, and decay of false-alarm rates over time with p-values less than 0.01. The results showed no significance in the use of an in-simulation tutorial or target threat level. Future work should expand on this foundational research to determine whether the skills developed using this trainer transfer to real-world change detection.

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ABSTRACT

The first one hundred days of combat are the most dangerous time for a soldier due to uncertainty and unfamiliarity with his area of operations. Developing a desktop virtual trainer for change detection could reduce the threat to soldiers by improving their ability to detect signals among the cluttered, noisy neighborhoods of the current operational environment. Building upon previous change detection and signal detection work, this thesis explores the use of Army Virtual Battlespace 2™ as a prototype-training tool for change detection. Leveraging an Army-owned distributable trainer would potentially benefit soldiers prior to deployment. This research team conducted an experiment that tested fifteen participants over four weeks. Each participant explored the virtual environment twelve times. Researchers analyzed correct detections, false alarms, user confidence, threat levels, and tutorial group assignment. This first attempt at developing a military-oriented virtual trainer resulted in statistically significant improvement in detection percentages, user confidence, and decay of false-alarm rates over time with p-values less than 0.01. The results showed no significance in the use of an in-simulation tutorial or target threat level. Future work should expand on this foundational research to determine whether the skills developed using this trainer transfer to real-world change detection.

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LIST OF ACRONYMS AND ABBREVIATIONS

6DOF	Six Degrees of Freedom
AAR	After Action Review
ACT-R	Active Control of Thought – Rational
AI	Artificial Intelligence
AO	Area of Operations
AOR	Area of Responsibility
BCTC	Battle Command Training Center
BOLO	Be on the Look Out
COE	Current Operating Environment
COIN	Counter Insurgency
COTS	Commercial Off-the-Shelf
DIS	Distributed Interactive Simulation
DoD	Department of Defense
DVTE	Deployable Virtual Training Environment
FA	False Alarm
FORSCOM	Forces Command (U.S. Army)
FOM	Freedom of Movement
FOV	Field of View
HLA	High Level Architecture
HMMWV	Highly Mobile Multi-Wheeled Vehicle
HVT	High Value Target
IA	Iraqi Army

ID	Identification
IED	Improvised Explosive Device
IP	Iraqi Police
ITS	Intelligent Tutoring System
IED	Improvised Explosive Device
IET	Initial Entry Training
IR	Infrared
IRB	Institutional Review Board
JTCOIC	Joint Training, Counter-IED Operations Integrations Center
KR	Knowledge of Results
MCIT	Mobile Counter-IED Interactive Trainer
MOVES	Modeling, Virtual Environments, and Simulation
NCO	Noncommissioned Officer
NPS	Naval Postgraduate School
NVGP	Non-Video Game Player
OE	Operating Environment
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
PC	Personal Computer
PEO-STRI	Program Executive Office for Simulation, Training, and Instrumentation
PIR	Priority Intelligence Requirements
PMI	Pre-Marksmanship Training
POI	Program of Instruction

PTS	Post-Traumatic Stress
ROC	Receiver Operator Characteristic
SA	Situational Awareness
SD	Standard Deviation
SDT	Signal Detection Theory
SIGACT	Significant Activity
SME	Subject Matter Expert
STX	Situational Training Exercise
TRADOC	Training and Doctrine Command
TRAC-Mtry	TRADOC Analysis Center – Monterey
TTP	Tactics Techniques and Procedures
USA	United States Army
USB	Universal Serial Bus
USMC	United States Marine Corps
VBS2	Virtual Battlespace 2
VE	Virtual Environment(s)
VGP	Video Game Players

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I. INTRODUCTION

A. PROBLEM STATEMENT

The current operational environment's (COE) unique challenges demand soldiers acquire a new, more robust skill set. In an asymmetric environment, the enemy blends into the population and uses unconventional weapons and tactics. Those who operate frequently in a counterinsurgency (COIN) environment exercise many skills specific to an asymmetric environment. Most operational units revisit the same terrain many times, sometimes for their entire rotation in Iraq or Afghanistan. Asymmetric threats highlight the importance of heightened awareness and sharp memory in order to recognize environmental and social changes. If these skills do in fact mitigate the risk of attacks, then recognizing objects, people and behaviors that differ from previous patrols through an area is critical to mission success and force protection. Performing detection tasks under stressful combat conditions necessitates the rapid development of change detection skills prior to deployments.

The Army considers the first one hundred days in combat the most risky to soldiers (Center for Army Lessons Learned, 2008). Learning the environment and becoming sensitive to change are fundamental for combat skills development during this initial period. Currently, some training designed to hone these abilities occurs during pre-deployment training. Normally, the training includes a mixture of classroom briefings and Situational Training Exercise (STX) lane training. STX for detection tasks revolve around counter-IED operations. This training varies slightly by operational unit. Additionally, several new virtual counter-IED trainers such as the Institute for Creative Technology's Mobile Counter-IED Interactive Trainer (MCIT) address change recognition skills (Peck, 2010). This existing training is significant but it focuses almost exclusively on training tactical preparation and response to IED attacks. One problem with this solution is the limited distribution of the existing virtual trainers, so not all units are able to benefit from this tool. Throughput is another problematic issue. Limited virtual trainers do not enable adequate throughput, and often result in only one training session for each deploying soldier. When the enemy emplaces IEDs, there is typically an impact or change in the immediate environment. Such changes might include differences in the appearance of road or ground features. Changes in street activity may indicate a threat. Objects such as parked vehicles, storefronts, and number or type of people on a street represent possible indicators. Sometimes changes might be more subtle and difficult to detect. Veteran soldiers gain experience in identifying both obvious and subtle changes to the environment that may serve as a warning. This thesis attempts to determine whether a soldier's change detection skills improve through training prior to deployment.

By developing a desktop virtual training system with the specific purpose of improving the recognition of change, a viable, focused, and easily distributable training package becomes readily available to all deploying units. Furthermore, this potential solution provides near unlimited use for soldiers, commanders and staffs seeking to improve change detection and memory skills of combat forces.

The Department of Defense commits money, time, and personnel into virtual technologies, and they have continued this trend over the past three decades. This allocation of resources creates opportunity for new training approaches to old problems. The development of a soldier's situational awareness, which comes in many forms, is just one example of how the Department of Defense can leverage the use of virtual environments. Being alert to changes in an environment is one manifestation of an individual's level of situational awareness. A soldier's ability to detect change in their area of responsibility (AOR) is an important skill that might improve with the use of a desktop training solution.

The United States Army and Marine Corps employ Virtual Battle Space 2 (VBS2) as a portable, personal virtual training environment for their personnel. Given the limited training resources of the armed services, VBS2 represents a viable way to train ground combat tasks applicable to the COE. The use of virtual simulation allows multiple training iterations at very little cost to the government. Although virtual environments offer many opportunities, the current challenges are to determine (1) what tasks to train in VBS2, (2) how to measure training progress using this new tool, (3) how to validate positive training transfer on these tasks, and (4) what instructional support materials might be needed to provide for each training package.

Threat detection or change detection skills are one example of a common combat task that might improve by using a virtual environment for training. This thesis seeks to investigate the potential for using VBS2 or a similar virtual environment as a desktop trainer for change detection skills.

B. RESEARCH QUESTIONS

1. Does change recognition performance improve over time in a virtual environment? How does it improve?

   a. Can a participant improve at recognizing that something has changed in general, measured by correct detections or detection percentages?

   b. Does a participant's confidence level improve at recognizing and identifying changes in a scene using a simple ordinal scale of high, medium, and low?

2. How do detection percentages differ when assessing a participant's performance on a variety of threat difficulty levels?

3. How does automated virtual training affect change detection percentages?

4. Does the percentage of recognized changes and false alarms grow proportionally? Alternatively, can the detection percentage improve while simultaneously decreasing the false alarm rate through repeated exposure to a simulated environment?

C. HYPOTHESES (GIVEN TRAINING OR EXPOSURE IN VE)

1. Participants' detection rates will increase over time.

2. Participants' false alarm rates will decrease over time.

3. Participants' confidence will increase over time when detecting changes in a virtual environment.

4. Detection rates will be higher when evaluated against a high threat level, a subjective measure of how threatening a scene appears.

5. Participants receiving the automated virtual training will detect more changes (perform better) in signal plus noise scenarios.

D. OTHER EXPLORATORY QUESTIONS

Do factors such as age, rank, branch-of-service, combat experience, or video game experience affect a participant's ability to learn to detect changes in a virtual environment?

Do participants believe they received quality training that could positively influence real-world change detection performance?

E. SCOPE

The scope of this thesis focuses on answering these research questions. The research team developed the five hypotheses to guide the experiment and answer the research questions. This research endeavor developed a prototype change-recognition trainer using VBS2. The team tested the trainer with a sample population from Naval Postgraduate (NPS) students in order to measure the training effectiveness of the virtual environment over a period of weeks through multiple exposures. After testing, the team analyzed the data, identified trends and explained the results. Finally, the report concludes with recommended future work and an exploration of potential distribution methods for VBS2 change detection scenarios.

F. BENEFITS OF STUDY

By demonstrating that virtual environment training improves change detection skills, this study highlights the capability of VBS2 as a desktop part-task trainer for soldiers. Because all U.S. Army soldiers have access to VBS2 on their personal computers, this research has the potential to make change detection training more accessible to the individual user. Similar training could reduce the risk of casualties from a variety of asymmetric threats in the first one-hundred days in combat and beyond.

G. THESIS ORGANIZATION AND TABLE OF CONTENTS

- Chapter I: Introduction. This chapter describes the problem, lists the research questions, presents the hypothesis, and defines the scope and benefits of this study.
- Chapter II: Background. This chapter provides a literature review for the study. This review includes current literature on computer games for training, arousal, vigilance, memory, attention, change detection, Signal Detection Theory, and Army training challenges.
- Chapter III: Methodology. This chapter describes how the research team designed the experiment, including participants, procedures, and materials.
- Chapter IV: Results and Discussion. This chapter contains the results of experimentation and an interpretation of those results.
- Chapter V: Recommendations. This chapter provides an overall assessment, methods for using VBS2 scenarios, and recommends future work for change detection in virtual environments.
- Appendix A: Pre-Experiment Instructions. This appendix contains all materials each participant received prior to the experiment.

- Appendix B: Computer Set-up. This appendix describes how to set-up and begin change detection training in VBS2
- Appendix C: Approved IRB Protocol. This appendix contains the approved Institutional Review Board protocol for experimentation with human subjects.
- Appendix D: Informed Consent. This appendix shows the consent form signed by all participants.
- Appendix E: Demographic Survey. This appendix contains the demographic survey completed by all participants.
- Appendix F: VBS2 Scripts. This appendix displays all scripts (code) for virtual activity in the scenes and human-computer interaction with the simulation.
- Appendix G: Tutorial Voice-Over Scripts. This appendix contains all the scripts for voice-overs heard in VBS2 by participants.
- Appendix H: JMP Raw Data. This appendix displays the raw data matrix used to record participant data during experimentation.
- Appendix I: Confidence vs. Threat Raw Data Matrix. This appendix shows the SME threat-level ratings and participant confidence raw data table.
- Appendix J: How to create a Change Detection Scenario. This appendix expands upon Chapter III, providing more depth on how to create a change detection scenario in VBS2. Additionally, it provides the reader step-by-step instructions for repeating the experiment.
- Appendix K: Changes Used in this Experiment. This appendix shows all before and after pictures of the changes used in this experiment providing additional context.
- Appendix L: Potential Target (Change) Locations. This appendix contains pictures of the entire virtual environment used in this experiment. It shows a comprehensive list of target areas possible in the virtual environment.

II. BACKGROUND

A. INTRODUCTION

The background work for this thesis examined several disciplines and knowledge areas. First, the research team examined previous research that leveraged video game and simulation technologies for training ensured that the research team selected a viable tool for training change detection. Specifically, the military's use of video game-based training was of significant importance. A review of this literature revealed possible indicators for how a participant might perform in a virtual environment. Next, the team sought to understand the relationship between arousal, vigilance, attention, and memory helped guide the development of an engaging and interesting scenario. Proper scenarios were of paramount importance in order to stimulate and motivate participants during experimentation. An understanding of Signal Detection Theory (SDT) and previous work done with change detection provided a starting point for continuing research and formed the basis for measuring the effects of this experiment. Finally, the research team reviewed at studies outlining future requirements for Army training.

B. USE OF VIDEO GAMES FOR TRAINING

Brehmer and Dorner (1993) use the term "microworlds" to describe video games and simulations. The authors explain that the problem with research in a lab or in the field is that both of those options contain great advantages and disadvantages. In a lab, the research team can control almost all variability; however, individuals conducting those tasks in the real world often call the external validity, or generalizability, of the lab results into question. On the other side of the coin, experimentation in the field contains innumerable confounds, due to a lack of control. While user communities view field studies as valid, scientists often question the conclusions. The use of games or simulations provides a balance between these two extremes. Virtual environments allow for more control than the field and more complexity than the lab (Brehmer & Dorner, 1993).

By identifying the variables that affect training processes and procedures early on, training developers can structure virtual training tools to maximize training benefits. A popular training apparatus today is the computer video game for individual and collective training. If designed properly, games represent an entertaining and educational medium for training military skills. Experience, orientation periods, and input devices are important factors to consider when designing a game for training. The next few sections address the concerns in turn.

1. Video Game Experience

In a study conducted by Orvis, Moore, Belanich, Murphy and Horn (2010), they found that soldiers were not typically "gamers." In their study, Orvis defined the term "gamer" as someone who plays video games at least once a week. They found the percentage of soldiers who reported being gamers was less than 43 percent (Orvis, Moore, Belanich, & Horn, 2010).

In another study by Orvis, Horn and Belanich (2009), they demonstrated that prior gaming experience increased the time subjects stayed on task. In other words, it took longer for gamers to become bored from the training. Gamers also demonstrated increased training performance and greater overall satisfaction with the training.

A study by Green and Bavelier (2003) on visual selective attention for gamers and Non-Video Game Players (NVGPs) showed that gaming skills are a learned task. Across multiple experiments, gamers demonstrated greater attention capacity at visual tasks than their NVGP counterparts. Green and Bavelier feared that NVGPs' visual abilities might not be as good as the gamers, and thus, they did not play video games as a result. To eliminate this possible confound, Green and Bavelier split the NVGPs into two groups that practiced playing video games. For this experiment, one group practiced with the action game *Medal of Honor*, a game similar to the games reportedly played by the Video Game Players (VGP) in previous experiments. The name given to this group was “action game.” The “control game” group practiced on *Tetris*. Since *Tetris* is a monofocus game vice the multifocus *Medal of Honor*, the research team did not expect to see altered attention ability in the control game group. After one hour of practice a day for ten days, the action game group showed improvement in video game playing. The Tetris or control group, showed no improvement (Green & Bavelier, 2003).

In Green and Bavelier’s experiment, the gamers showed the highest attentional capacity of all participants. However, the improvement of the NVGP group playing action video games demonstrated that playing complex video games could alter visual attention by speeding up the perceptual processes required by the games (Green & Bavelier, 2003).

2. Orientation Periods

Pretraining is any training that occurs before an actual training exercise. Pre-Marksmanship Instruction (PMI) is a good military example of pretraining. PMI is static weapons training conducted by military forces, often in garrison, before going to a live weapons range. Building pretraining into a training program of instruction (POI) fosters improved performance and increases the value of training in a virtual environment. Orientation periods, self-paced practice, and instructor set training scenarios allow for personalized training (Orvis et al., 2010). Not all soldiers have the same level of experience using simulations and video games. Acknowledging this fact and building the training system to accommodate these differences allows the more experienced players to progress faster and quickly get novice players to an acceptable proficiency level.

Flexibility in pretraining sessions decreases both boredom from training for gamers and frustration of the training for NVGPs. When learning a new task, length of time and the processes necessary for skill acquisition are not clearly identifiable. However, "it is commonly agreed upon that time spent on a task is the prominent cause of whether or not the skill will be acquired" (Vowels, 2010, p. 17). Variation in pretraining length or difficulty allows those requiring more time or focus on a specific area to receive it. Individualized pretraining variability improves the overall training experience while standardizing the training.

3. Ease of Use and Familiarity with Input Devices

Identifying the appropriate input device for use in virtual environment training scenario is critical. There are measurable differences between various input devices. Research on input devices among young adults indicated that "some devices are better than others; no one device has been shown to be superior for all tasks or applications among young adult populations" (Wood, Willoughby, Rushing, Bechtel, & Gilbert, 2005). Identifying the input device that allows a user to quickly reach asymptotic performance could lead to less pre-training requirements, thus allowing trainees to focus on the critical tasks taught by a virtual trainer.

Ease of use and comfort level with the input device affect performance levels. If trainees find the interface and "learning environment to be frustrating and difficult to use, they may experience decreased motivation that prevents them from fully engaging in or completing the instruction"(Orvis, et al. 2009). Along with potential interface frustrations, vigilance decrement also effects attention levels. As outlined by Proctor and Van Zandt (2008), task vigilance decreases dramatically after thirty minutes. Therefore, it is important that the trainee continue to feel engaged, motivated, and focused during training sessions. The input device has a profound impact on this feeling of engagment or frustration, and thus, it is a valuable part of the training experience. Consideration and careful evaluation must go into the selection of an input device for any training envrionment.

C. AROUSAL

After gaining a trainee's interest, maintaining that attention is essential for a successful training tool. The first step to draw the interest in the tool is through what Jane Mackworth (1968) calls the arousal response. The arousal response is a neural reaction to a stimulus alerting the brain. Mackworth argues that high motivation and knowledge of results (KR) are key factors to maintaining the high arousal necessary to staying alert at a vigilance task such as signal or change detection. Researchers employ a number of techniques in order to maintain arousal, motivation, and focused attention during a training task. These techniques include providing the participant with KR, limiting the exposure, and being deliberate about the number of signals presented.

D. VIGILANCE

Significant research on vigilance and the vigilance decrement followed World War II where many inventions, like radar and sonar, required a high level of operator vigilance in order to accomplish critical military tasks. Since that time, our reliance on technology to advance military capabilities has increased steadily. This section explores a few pioneers in vigilance research and modern developments to an age-old problem.

1. Vigilance Research: Formative Years

Norman H. Mackworth and Jane F. Mackworth explored issues surrounding vigilance throughout the 1950s and 1960s. Perhaps one of the most enduring works on vigilance was a 1961 experiment in which N.H. Mackworth (1961) used the now famous Jump Clock Test. Mackworth's research was a response to the British government's request for experimentation on ways to alleviate the strain on radar and antisubmarine watchmen.

To test the vigilance of individuals, Mackworth had his participants, service members, sit in a cabin and watch a clock-like device. The device resembled a wall clock that had only one hand, six (6) inches long, and a plain white face without the normal clock markings for minutes and hours. He informed participants that the hand would move around the face of the clock, and Mackworth instructed participants to watch for a "double movement" (Mackworth, 1961). During this movement, the hand advanced twice the normal distance, or about the equivalence of two minutes. Participants pressed a button when they recognized this change.

The clock experiment lasted two hours for each subject. During the two hours, each participant conducted four 20-minute sessions watching at the clock, and if they saw the extra movement, they had eight (8) seconds to respond. If a participant failed to respond within eight seconds, it counted as a miss (Mackworth, 1961).

Another key component of Mackworth's experiment was the lack of feedback each participant received during each trial. This feedback was an example of knowledge of results (KR). The feedback provided to the participant could have come during the experiment or between trials in order to provide some tangible information about their performance; however, Mackworth chose to provide neither to his subjects.

To summarize Mackworth's extensive experimentation, he found that over time, participants missed more and more signals. He also experimented with Benzedrine, an amphetamine, and found that five of every six participants taking the drug performed better in the long run; however, he also noted that performance under the influence of Benzedrine was no better than the average participant without the drug in the first 30 minutes of the test (Mackworth, 1961).

N.H. Mackworth made two important conclusions that led to an entire field of follow-on research. First, thirty minutes seemed to be a significant measure for vigilance. Essentially, he discovered and documented the vigilance decrement. Second, he documented the fact that amphetamines helped participants perform better at a vigilance task for longer periods; however, the use of drugs lost acceptance in the military making other methods necessary.

2. Defining the Vigilance Decrement

Jane Mackworth wrote a paper for *Psychological Review* in 1968 that outlined much of the work conducted by Norman H. Mackworth and other experts on vigilance. She elaborated on the concept of habituation as it related to a decrease in vigilance. Specifically, Jane Mackworth (1968) argued that there were two factors at work in the brain causing a vigilance decrement: (1) arousal response and (2) evoked potentials. She claimed that due to habituation the arousal response, or brain rhythm, becomes less sensitive to changes, especially when an environment is noisy. Conversely, she explained that habituation in the evoked potentials, produced by a repetitive stimulus in the background noise, cause a decrease in detections, most likely when the event rate is regular or slow (Mackworth, 1968).

Jane Mackworth's further explanation of the vigilance decrement is important, and today, the Mackworths' concept is universally accepted. Jane Mackworth's work is significant because it explains that there is more than just boredom involved when observing a vigilance decrement. In fact, it might be due to overstimulation.

3. Vigilance at Repetitive, Boring Tasks

Robert R. Mackie researched vigilance throughout the 1970's through the 1990's. Another military-related research project involving vigilance was Robert R. Mackie, C. Dennis Wylie, and Malcolm J. Smith's experiment investigating sonar watch. Mackie et al. described three characteristics that led to a vigilance decrement: (1) boring task, (2) low signal rate, and (3) no feedback loop (Mackie, Wylie, & Smith, 1994).

During watchstanding, the likelihood of seeing a significant signal, or threat indicator, is often very low, if not unlikely all together. This watchstanding phenomenon has similarities to tasks required of soldiers in the common operating environments of Iraq and Afghanistan. Daily patrols move in and out of neighborhoods, often without experiencing any threatening signals. So how does low signal rate affect vigilance and what training is necessary to maintain vigilance under these circumstances? Those questions formed the foundation of Mackie's research.

Mackie et al. described a problem with experimentation prior to their research. They believed that signals in vigilance research were far too frequent to replicate reality and thus have validity outside the lab. They acknowledged the importance of knowledge of results (KR), but he noticed that there was a dearth of research into artificial signal injection aimed at improving motivation (Mackie et al., 1994). Their 1994 study sought to determine how signal injection and knowledge of results would affect a boring task like sonar watch.

For this experiment, Mackie et al. set up a computerized sonar display, closely resembling the actual equipment used by the British Navy. Each participant sat at the display and observed the signals on the sonar equipment. Normal signals looked as they do in the real world. Injected signals displayed an additional asterisk on the signal line after detected by a participant. Furthermore, an alarm sound notified a participant when they had neglected to mark an injected signal after it had been present for 5-minutes. Participants moved a cursor on screen and pressed a “report” key when detecting a real or injected signal (Mackie et al., 1994).

There are numerous lessons to learn from this research team’s methodology. First, they are purposefully keeping participants engaged in the scenario by injecting bogus signals that look like the real world threat signals. Once a user detects an injected signal, they are rewarded with knowledge of results (an asterisk), and if they fail to catch the injected signal, they are alerted with an audible tone - knowledge of results. In effect, the researchers create the conditions necessary to actively motivate their participants and keep them alert for a specified signal in an attempt to circumvent the vigilance decrement.

Mackies et al. conducted four separate experiments as part of this study. Participants performed the signal detection task twice for a length of 2-hours to 5.5-hours per session, depending on the experiment trial number. This was a long experimentation time per subject, but it adds to the validity of his results since tasks like these are normally conducted during an 8–12 hour shift. It is important to note that injecting signals produced statistically significant improvement to signal detection, especially over time (Mackie et al., 1994). This constant detection forced a user to maintain a high level of vigilance. This focused attention prevented, or at least delayed, the vigilance decrement.

4. Mental Workload and Stress

Where the Mackworths and Mackie focused on boring, mundane tasks involving detecting a short-duration, infrequent signal in a sea of noise, Joel S. Warm and Raja Parasuraman (2008) were interested in high mental workload and its effect on vigilance. Parasuraman’s research interests included human attention, and Warm’s work on human performance in military systems was noteworthy. Warm, Parasuraman, and Gerald Matthews authored a paper outlining a new approach to vigilance research. Their approach suggests that, "vigilance requires hard mental work and is stressful" (Warm, Parasuraman, & Matthews, 2008, 433).

To support this argument, Warm et al. proclaimed that the most important finding in all previous vigilance research has been the vigilance decrement. However, they argue that previous conclusions might be incorrect about why the decrement occurs. This team submits that recent research supports the condition where a vigilance decrement occurs due to taxing mental requirements on the individual conducting a vigilance task. They draw evidence to bolster this argument from research evaluating: (1) task type, (2) perceived mental workload, (3) neural measures of resource demand, and (4) stress related to the task (Warm et al., 2008).

This thesis addresses three (3) of these areas, omitting only the neural measures of resource demand. Although the objective neural measures are important, the focus of this research was to identify vigilance considerations for the development of desktop virtual trainers. The average developer using an application like VBS2 to create training scenarios does not have access to positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) machines to test their work.

a. Type of Task

One important distinction made by Warm et al. is the type of task conducted while assessing vigilance. They make the distinction between successive and simultaneous tasks. Interestingly, they cite research supporting the fact that successive tasks are more demanding than simultaneous ones, due to the requirement to use memory in successive tasks (Warm et al., 2008). Since a successive task scenario would be more demanding, the vigilance decrement would occur sooner during this type set-up. The development of task objectives requires great care and attention to detail. The sequence or presentation of signals in an environment can affect the level of vigilance required to complete any task or training event.

b. Perceived Mental Workload

The next major section of Warm's paper deals with the mental workload on the individual performing a task. The authors describe three components of this workload: (1) mental, (2) physical, and (3) temporal (Warm et al., 2008). They argue that a finite number of resources exist, and once those resources are gone, a vigilance decrement is likely to follow. Warm et al. explain that the relationship between the vigilance decrement and workload is linear.

This argument in Warm's paper has significant implications for development of change detection scenarios in a virtual environment. Overloading a user with information amid the requirement to detect anomalies in their surroundings quite possibly results in a sharp decrease in vigilance. This decrement will lead to a failure of the training system to achieve its intended purpose. Showing a participant where to look in their environment can prevent such an overload, and explaining what to look for should lead to improved results.

c. User Stress

The final topic discussed in Warm's paper is task-induced stress. The authors acknowledge that using objective and subjective measures to evaluate stress during a vigilance task adds validity to the evidence. The focus of this thesis is on the subjective evaluations, since again, most military developers of desktop solutions do not have access to laboratory equipment to measure stress objectively in their trainees.

Warm and his colleagues reported that participants in vigilance experiments often report being more tired and stressed after the exposure than before they began the experiment (Warm et al., 2008). They compared these reports to the amount of workload required during the experiment and determined that stress resulted from high mental workloads during the testing.

5. Workload Experiments

Tiwari, Singh and Singh (2009) also studied the effects of task demand and workload on vigilance. Much like Mackworth, Tiwari et al. (2009) tested subjects on their ability to detect small changes in a common object. They used a square that would occasionally be slightly bigger (a half centimeter, 3–3.5 cm) on a computer screen. They tested 40 participants, 20 in a low-demand task (15 events per minute) and 20 in a high-demand task (thirty events per minute). The experiment lasted thirty minutes broken into three (3) 10-minute scenarios; afterwards, participants filled out a questionnaire to ascertain stress and motivation levels.

Tiwari's research team affirmed what Warm et al. said about workload and stress. There were many interesting subjective results from the questionnaires to include statistically significant changes in arousal, motivation, concentration, and attention levels. Additionally, those participants in the high-demand task condition rated their mental workload higher (Tiwari et al., 2009).

On the objective side, participants in the high-demand group detected fewer correct signals and committed more errors than those in the low-demand group. This further supported the idea that there are a limited number of resources to draw from when conducting a task requiring vigilance. Overloading a participant appears to bring about a vigilance decrement, just as easily as a monotonous task would. Tiwari's team confirmed Warm and Parasuraman's work involving mental workload, stress and vigilance. It also supports key considerations for future development with virtual environments discussed in the methodology section of this thesis.

6. Vigilance Decrement in Virtual Environments

The vigilance decrement is a potentially devastating phenomenon that could easily devalue any instance of virtual environment training where it presents itself. As military professionals tasked with developing training plans for deploying units, this research team must remain alert to vigilance decrements and understand why they occur.

Both authors have seen the vigilance decrement many times through experience with military training; however, until recently, explained away the phenomenon as boredom. As officers who have been through boring, monotonous training, we attributed a dip in trainee performance to bad design of the training package. This attribution oversimplified the problem.

The vigilance decrement explains why dips in performance occur during training. Understanding the science of the decrement reveals methods to improve the training. Using previous work as a starting point and heeding the warnings of vigilance researchers, developers can accomplish their training goals and optimally engage the training audience in the process.

As the Mackworths introduced and many have expanded upon, the vigilance decrement can occur because of over stimulation or under stimulation. Warm and Tiwari confirmed that task overload problems can lead to stress and cause rapid onset of the vigilance decrement. The rest of this section will describe an experiment conducted in November and December 2010 where this research team saw a vigilance decrement influence the results.

7. Vigilance Decrement: Thesis Pilot Study

The first time the research team identified a vigilance decrement and tried to properly classify the phenomenon was in a pilot study for this thesis during a Human Factors in Systems Design class at the Naval Postgraduate School (NPS). The research team consisted of Charalampos Tsamtsaridis, Gina

Becker, Mike Stinchfield, and Jason Caldwell. The group chose to pursue a topic close to this thesis area. We were looking at input devices for Virtual Battle Space 2™ (VBS2) to evaluate the usability of each device for thesis experimentation (Tsamtsaridis, Caldwell, Stinchfield, & Becker, 2010).

For this pilot study, the team developed a series of six (6) eight-minute scenarios containing 60 potential targets in the virtual world of VBS2. Each simulation scenario had three (3) distinct areas that participants traveled through: the first contained 10 targets, the second contained 20 targets, and the third had 30 targets. Participants would attempt to detect targets on the left and right side of a narrow road while riding through the environment as a passenger in the simulation on a motorcycle. The team conducted the pilot study over two separate sessions where participants used the mouse in one session and the head tracker in the other session. The research team randomly divided participants between group. One group started with head tracking and the other started with the mouse. The entire experiment lasted approximately two (2) hours, one (1) hour for each session.

The research goal was to determine the time to reach asymptotic performance with two input devices. The research team defined asymptotic performance as a less than 10% increase in targets detected for three consecutive scenarios. While plotting the data, an obvious dip in performance occurred over the course of experimentation. This performance decrease showed up consistently after the first couple of scenarios (Figure 1).

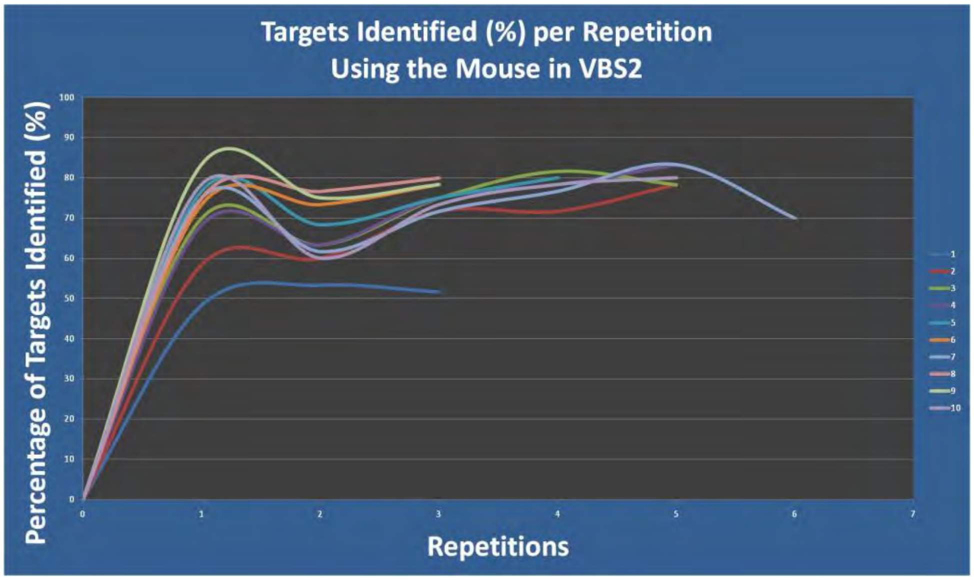

Figure 1. Vigilance decrement in target detection task with the mouse as the input device

At the time, the team had not conducted an extensive literature review on vigilance. As we look at the data and refer back to Warm and Parasuraman's explanation for the vigilance decrement, our pilot study team was guilty of overloading participants and tiring them out very quickly by immersing them in a high-demand task over an extended duration. Task overload and a scenario length exceeding thirty minutes contributed to the vigilance decrement. Subjects quickly reached asymptotic performance with the mouse as an input device even with a vigilance decrement, but using the TrackIR® head tracker created even more problems.

In addition to vigilance decrement issues, learning to use the TrackIR head tracker to perform a detection task obviously overwhelmed the participants. In fact, only four of the ten participants ever reached asymptotic performance with the head tracker during the six (6) scenarios involved in this pilot study.

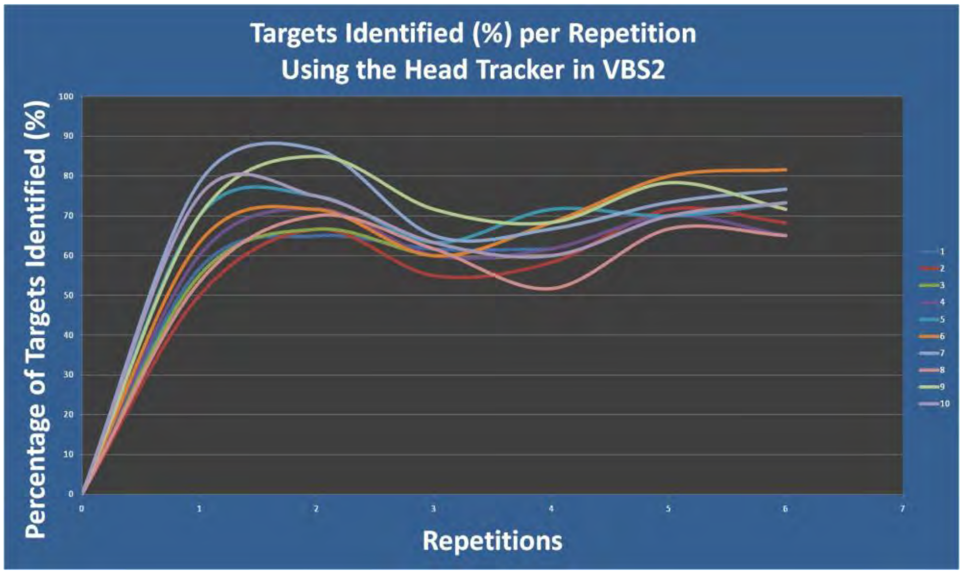

Figure 2. Vigilance decrement in target detection task with the head tracker as the input device

Figure 2 shows a clear decrement after the second scenario. Additionally, it illustrates the fact that six of our ten participants never reached asymptotic performance and had to stop the experiment after the designated time.

These results were informative and necessitated exploration of vigilance and its effects prior to continuing thesis work. Vigilance greatly affected this research team's approach to scenario development and experimental design using VBS2. Understanding the variables that change a user's vigilance forced critical thinking about the way to evaluate any simulation training.

E. ATTENTION

Training soldiers and marines to detect threat indicators early and accurately can save lives on the battlefield. Arousal and vigilance are critical components of detection skills that affect overall performance search tasks. The Yerkes-Dodson law (Yerkes & Dodson, 1908) says that a person's best performance can be estimated based on arousal level and task complexity. Arousal and attention are closely intertwined. Both relate to vigilance, which

Proctor and Van Zandt define simply as “sustained attention,” a necessary component for detecting change (Proctor & Van Zandt, 2008, p. 244).

Belopolsky, Kramer, and Godign (2008) describe how selective attention allows humans to take a large amount of visual input and encode that into memory.in both top-down and bottom-up methods. They argue that the longer an individual fixates on an object in a scene, the more likely they are to transfer that to memory. Morelli and Burton support these selective attention findings and extend the work to the military domain by arguing that the ability to, “filter out distracting information and selectively attend to relevant information is critical to effective performance on the battlefield (Morelli & Burton, 2009, p. 81).

Of additional concern to this research is an increased attention capacity of video game players (Green & Bavelier 2003). Identifying video game players becomes increasingly important due to Green and Bavelier’s result. The research team acknowledges that VGP might actually perform better at change detection in a virtual environment because of more attention resources. Blocking by this criterion is important to the validity of any resulting experimental outcome.

F. MEMORY

Once a trainee employs focused or selective attention, the conditions are set to encode the environment into memory. Wickens and Hollands (2000) describe two types of memory, working and long-term. They purport that working memory is a temporary storage area until it can be stored in long-term memory for future use.

Wickens et al. delineate three stages of memory: encoding, storage, and retrieval. For the purpose of this thesis, Wickens’ description of encoding refers to the process of “learning or training” used to move spatial information from working into long-term memory (Wickens & Hollands, 2000, p.242). There are capacity limitations to working memory, so encoding information about an entire neighborhood or area of operations is problematic and most likely goes into long-term episodic memory for later recall.

Chunking represents one popular technique of grouping smaller pieces of information into larger "chunks" for encoding. While chunking normally refers to techniques for managing nominal pieces of information, it is reasonable to believe that soldiers unwittingly employ the same techniques while patrolling in the current operating environment. Wickens and Hollands propose the idea of "skilled memory" derived from an expert's ability to chunk key pieces of information (Wickens & Hollands, 2000, p. 256). It is easy to see how skilled memory would promote the detection of changes in a soldier's environment.

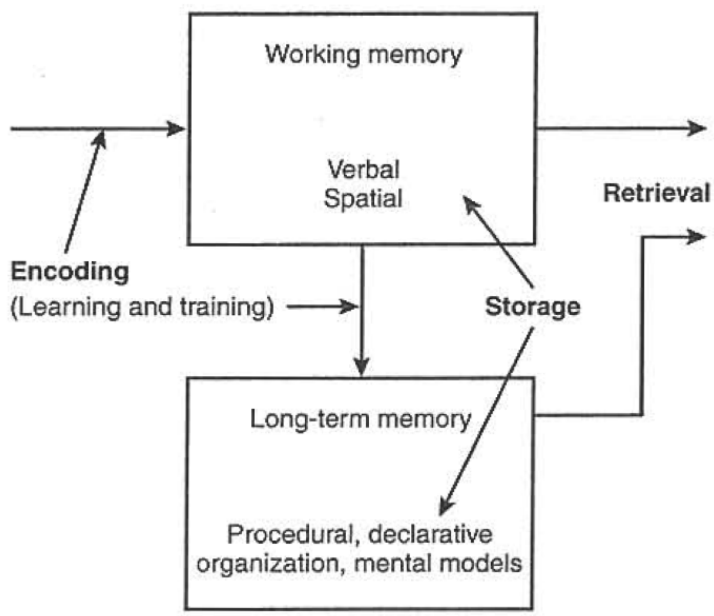

Figure 3. Memory functions (From Wickens & Hollands, 2000)

After encoding, Wickens and Holland explain that information goes through a "storage" stage. They explain that working memory uses spatial and verbal cues, while long-term memory relies on declarative and procedural models

(Wickens & Hollands, 2000, p. 242). While important concepts to understand, measuring encoding and storage is problematic for someone tasked to train soldiers on change detection tasks.

From a training evaluation standpoint, retrieval represents the most important and measurable stage described by Wickens and Holland. It is easy to assess retrieval, since a soldier either remembers or forgets details about their environment. Wickens and Holland describe forgetting as a "retrieval failure" (Wickens & Hollands, 2000, p. 242). He points out that just because information is in long-term memory does not ensure someone will remember it. He elaborates on two types of memory retrieval: recall and recognition. Recall deals with remembering exact information in memory. Recognition describes the ability to answer a yes-or-no-type question accurately based on information stored in memory (Wickens & Hollands, 2000, p.281). For a change detection task, environmental recognition is enough to enable a trainee to decide if a change has occurred.

G. CHANGE DETECTION

Previous change detection experiments involving virtual worlds are limited in scope and size. When compared to this research teams' military-focused objective, the environments used throughout the literature are quite small. In most cases, the VE is just a room, house, or small city block. While useful for research purposes, it does not provide the rich context necessary for military training.

One experiment stood out among the rest as having some military applicability for training. Karacan, Cagiltay and Tekman (2010) studied change detection around a square block modeled in a virtual environment. Their environment resembled a city park. This environment contained a sidewalk where avatars walked around the square. On the inside of the block was a wall that prohibited participants from looking at anywhere but the current stretch of sidewalk. As a user moved around the block, they saw houses, trees, and six other objects next to the sidewalk. Those six objects included a bench, street lamp, billboard, fire hydrant, mailbox, and a trashcan. Unbeknownst to participants, the trashcan was the object that would change in the experiment. The changes that might occur to the trashcan included appearance of a new object (trashcan), disappearance, displacement, and replacement of the trashcan with a new object (Karacan et al, 2010).

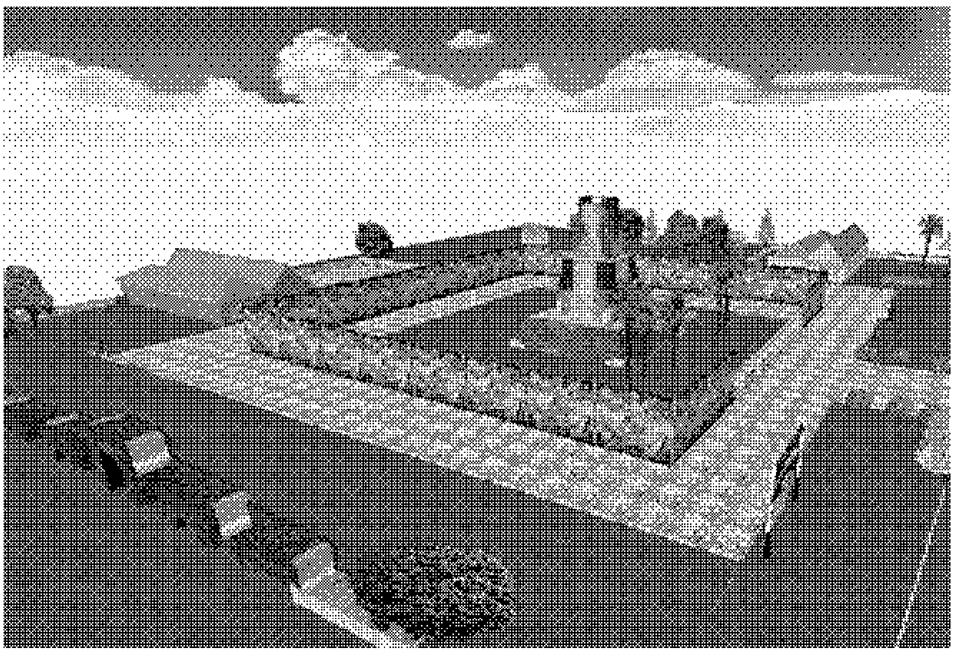

Figure 4. Virtual world (From Karacan et al., 2010)

Early on, Karacan et al. admitted that humans are poor at detecting changes in complex scenes. The phenomenon of “change blindness” can increase with the amount of activity in a scene (Karacan et al., 2010, 1305). Karacan et al. allowed participants to become familiar with the virtual environment in order to determine if change detection could improve. Karacan et al. relied on literature that predicts people are more apt to notice change in familiar environments. To measure the detection of change, they measured a participant’s eye gaze on specific objects.

The results of Karacan et al.'s experiment revealed that familiarity with an environment plays an important role in detecting change. That familiarity was the only statistically significant factor in detecting change. With regard to the four types of changes, Karacan et al. found that the appearance of a new object attracted the attention of the largest number of participants. Object deletion also gained the attention of a number of participants; however, neither of these factors contributed significantly to detecting change. Of note, both change factors produced a significant increase in gaze duration when compared to the baseline environment without changes (Karacan et al., 2010).

H. SIGNAL DETECTION THEORY

This thesis sought to produce and test a prototype trainer for improving combat soldiers' change detection skills. While eye tracking demonstrated value in the literature, the military lacked these laboratory-type conditions at the small unit level for measuring performance. At the time of this thesis, there existed no reliable, cost-effective option to distribute eye-tracking software for all soldiers and marines for use with VBS2. As a result, the research team needed to determine a proven metric to assess performance at change detection in VBS2. Signal Detection Theory (SDT) provided just the type of objective measurements necessary to accomplish this mission.

Classifications of Signal and Response			
		State of the Environment	
		Signal	Noise
Response	Yes (Present)	Hit	False Alarm
	No (Absent)	Miss	Correct Rejection

Table 1. Signal Detection Theory states and responses

Classic Signal Detection Theory (SDT) presents a participant with two types of situations. In one case, there is no signal present. The literature refers to this condition as "noise trials." In the other case, there are signals in the noise. These are "signals plus noise trials" (Proctor & Van Zandt, 2008). In SDT, a signal is anything intended for detection within an experiment. Some examples of potential signals include a change in the environment, the signature of an explosive device, and human or physical targets. There is no requirement that a signal be visual. In fact, many SDT experiments measure sensitivity to auditory stimulus (Green & Swets, 1966).

Table 1 outlines the two-by-two matrix of possible SDT classifications. Signal Detection Theory primarily focuses on hits and false alarms. While misses and correct rejections are important, they are just the complement of hits and false alarms. An experiment normally assesses a participant's sensitivity to signals. The higher the hit rate and lower the false alarm rate, the better the sensitivity (Proctor & Van Zandt, 2008).

Signal Detection Theory also addresses the idea of bias. For instance, if a person is very intent on detecting a signal, they may also be more apt to commit a higher number of false alarms. In this case, we call a participant "biased" towards responding that a signal is present (Proctor & Van Zandt, 2008, p.91). Bias can skew results, especially in small sample sizes where one or two participants with bias greatly affect the overall results.

I. TRAINING CONSIDERATIONS

In a recent U.S. Army Research Institute Report, Christopher Vowels (2010) reminds readers that soldiers must remain alert for changes in their environment. His paper focuses on threat detection and how the Army must create effective ways to train for emergent threats. He identifies many of the concerns of this thesis as they relate to threat detection: vigilance, attention, change detection, and recognition of threats, just to name a few.

Vowels recommends Virtual Battlespace 2 (VBS2) by name, and suggests that "synthetic learning environments, such as simulations or online interactive programs, can serve as the conduit to achieve any further training, regardless of unit location" (Vowels, 2010, p.7). He elaborates on the objectives of threat detection training. Three of these objectives are the reduction of errors, flexibility of the skills, and increased skill retention (Vowels, 2010, p.6). These goals became objectives for the change detection trainer developed as part of this thesis research.

Finally, Vowels mentions three relevant theories for training threat detection: Active Control of Thought – Rational (ACT-R), Signal Detection Theory (SDT), and the Recognition-Primed Decision Model (Vowels, 2010, pp. 17–22). This thesis uses SDT.

He explains that a training participant's ability to manipulate visual space and having an understanding of their role in that space are critical to the value of the training (Vowels, 2010, pp. 22–23). The key to improving the value of threat detection training is to incorporate the experiences of the current force into tangible tools to help improve performance (Vowels, 2010, p. 23).

Finally, the time available for training is a limited, finite resource. Deployment cycles and mandatory pre-deployment training objectives dictate the amount time allocated for each task. Vowels suggests that using virtual training that leverages video games is an effective way to train in garrison or while deployed (Vowels, 2010, p. 23). He also lists simulations and video games as his first recommended training format, explaining that there is evidence supporting increased cognitive skills from playing video games (Vowels, 2010, p. 31). Evidence of improved skill was demonstrated by Orvis et al. (2009, 2010) and Green and Bavelier (2003). The opportunity and challenge of developing a virtual training environment motivates this research team. Pursing the research goals outlined by Christopher Vowels guides this research effort.

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III. METHODOLOGY

A. INTRODUCTION

The objective of this thesis was to develop a change detection-training tool. In order to meet this objective, the research team looked at a variety of human performance factors and system capabilities needed to develop the training tool. First, it was necessary to identify the tasks that would stimulate change detection training. After identifying key tasks, the team chose an appropriate simulation to train those tasks. Developing a scenario compatible with the simulation was an important next progression. Finally, the research team evaluated potential user interfaces and determined methods for scoring trainees within the change detection trainer. Considering all these factors, the team created a change detection trainer and designed an experiment to test the apparatus. The research team created "training" and "no training" conditions for the experiment.

1. Tasks

Designing a distributable training tool focused on memory and change detection begins with the identification of training objectives and supporting tasks. Developers codify these objectives into requirements. For the purpose of this thesis, the research team served as the designers, developers, trainers, and evaluators for this tool.

Initially, the team identified five overarching, real-world training tasks that could benefit from an individual desktop virtual training environment. Task improvement was the ultimate objective of this task trainer. The specific tasks were:

- Change detection
- Pattern recognition

- Spatial memory encoding and recall or recognition
- Task memory encoding, recall and task performance
- Event memory encoding and recall or recognition

As presented in the introduction, the COE places soldiers and marines in a unique mission environment. A typical daily patrol during COIN operations will last eight to twelve hours. Within this period, a soldier or marine may observe hundreds of events and thousands of individuals. Additionally, it is common for a unit to revisit the same terrain daily, sometimes for months at a time. These conditions highlight the importance of memory, change detection, and pattern recognition. A mission scenario most appropriate for testing these skills is a daily patrol in an area frequently visited by friendly forces. The headquarters element provides soldiers with Priority Intelligence Requirements (PIR) specific to unit mission priorities. Some of these requirements include be on the lookout (BOLO) vehicle descriptions, target names or photographs, possible enemy locations, possible IED locations, current enemy tactics, techniques, and procedures (TTP), previous significant activities (SIGACT) information, friendly unit positions and missions, and many other relevant details for the mission.

Within this basic scenario, a virtual trainer can test several top-level tasks that a trainee might need to perform. The research team identified eight primary tasks:

1. Recognize physical environment pattern changes over time
2. Recognize social pattern changes in an environment over time
3. Recognize suspicious vehicles from descriptions or photographs
4. Recognize individuals from photographs or sketches
5. Recognize assigned boundaries of an operating environment (OE)
6. Recall and narrate personal social interactions accurately
7. Report recent high intensity activity events accurately
8. Recognize answers to a list of intelligence requirements

The team incorporated Tasks #1 and #2 into the trainer. To a lesser degree, the tool challenges trainees on tasks #3–5, but only through recognition of changes. Tasks #6–8 are beyond the scope of this experiment; however, they are extremely useful skills that a virtual environment could train. Each of these top-level tasks supports the following examples of tactical tasks:

1. Report any changes in population activity pattern.
2. Report any changes in vehicle traffic pattern.
3. Clear intra-sector routes of IEDs, confirm or deny possible IED locations.
4. Provide status of local law enforcement.
5. Report on any recent moves of families into or out of sector (resettlement).
6. Report any new business activities or new business openings, particularly clinics and Internet cafes.
7. Immediately report any SIGACTS accurately, and those which are Commander's Critical Intelligence Requirements (CCIR)
8. Capture or kill any High Value Targets (HVT)
9. Impound or pursue if necessary any BOLO vehicles
10. Provide full patrol debrief, including names, photographs, and significant PIR, particularly meetings with individuals of high influence
11. Coordinate with adjacent units for any activities that may affect other sectors.
12. Provide debrief on current tribal boundaries and leadership.
13. Provide debrief of current infrastructure status and any changes Sewage-Water-Electricity-Trash-Health (SWEAT-H).

The research team incorporated the first six (6) of these thirteen (13) tactical tasks in the change detection-training tool. The other seven (7) tasks, excluded from the current tool because they were beyond the scope of this thesis; however, virtual training provides a platform capable of training these skills.

2. Simulator: Choosing a Desktop Virtual Environment

After defining the tool's objectives and the tasks that achieve those objectives, the team needed to select a virtual environment. Three options emerged as most likely to meet the need: America's Army, Delta 3D, and Virtual Battlespace 2 (VBS2)

a. America's Army

Originally developed at the Naval Postgraduate School (NPS), America's Army presented a viable medium to develop a desktop virtual training environment. America's Army is an open source model for development within the United States Army. It presents trainees with uniforms and vehicles familiar to them. The downside of developing a tool in America's Army is the lack of technical support and the fact that very few people in the Army are using this software for training. America's Army is primarily a recruiting tool.

b. Delta 3D

Next, the research team evaluated Delta 3D as a potential candidate for a development environment. The Modeling, Virtual Environments, and Simulations (MOVES) Institute at NPS developed Delta 3D as an open source gaming engine. MOVES staffed a small Delta 3D development team, which assists students with projects and thesis work.

The research team developed the first prototype trainer using Delta 3D. Delta 3D provided the flexibility necessary to implement a training tool from scratch. There were no limitations due to proprietary software, and the environment had the added advantage of being programmable in Python or C++, two languages familiar to the researchers. This combination of flexibility, availability, and usability made the tool an attractive option.

During development of the prototype, the team used Blender ® to create many models. While Blender ® was very useful for the creation of exact changes it was also labor intensive. Given the limited time to conduct this thesis work, it had the potential to extend development timelines beyond acceptable limits.

Ultimately, the downside to Delta 3D was the fact that very few people in the Army are using that gaming engine for training applications. The image library for the engine contained pictures of Marines, but no agents for Army soldiers. This oversight was not a trivial fact when contemplating the prospects of justifying a training apparatus in front of Army flag officers. Finally, the Army recently invested large sums of money in Virtual Battlespace 2™, and the research team felt the momentum of that simulation.

c. Virtual Battlespace 2™

VBS2 does not share the advantages of an open game engine such as Delta3D. However, the research team determined that its flexible scenario editor, significant number of pre-built model assets, and pre-built terrain would offer the best capabilities for design of the virtual testing environment. Although the proprietary source code was inaccessible, VBS2 did offer the ability to run customized scripts that could be bound to keyboard commands. Additionally, this simulation's 3D graphics fidelity sufficed to model a plausible, current operational setting.

The research team tested VBS2 during a class project for OA3302, Research Methods for Performance Assessment, at NPS. The experiment involved target identification within the VBS2 virtual environment. Developing that experiment taught the research team the basics of VBS2 scripting. The experience enabled the implementation of additional capabilities beyond the "out-of-the-box" functionality of VBS2. Specifically, VBS2 offered several methods to test the intersection of a user's view vector with a flagged object. By testing several simple scripts employing these methods, the team developed an accurate and dependable algorithm for users to identify a target in their view with a key-press. Additionally, the team discovered how to extract the appropriate data from the simulation. VBS2 scripts copied the data to text files for analysis. Ultimately, the research team found that VBS2 scripting offered enough capability for the final virtual testing environment.

The extensive testing done by the research team proved that VBS2 was viable tool for change detection training. The fact that the Army widely used VBS2 for a multitude of training tasks solidified its selection. Moving forward, all work utilized VBS2, and with this decision out of the way, the research team shifted focus to scenario development and experimental design.

3. Scenario

a. VBS2 Scenarios

The team created a “baseline” and two (2) “change” scenarios for the experiment. The roads and infrastructure in the environment were the same regardless of scenario. The scenario guided the participants along the same route through the virtual environment every session.

Figure 5. Routes through the virtual environment

The team determined that a participant would occupy the gunner’s turret in a High Mobility Multi-Wheeled Vehicle (HMMWV). The artificial intelligence (AI) piloted the simulation along assigned waypoints. The developers placed these waypoints in the virtual environment using the VBS2 scenario-editing tools. By controlling route navigation, the researchers eliminated a source of variance that would have undoubtedly arisen if participants had been allowed to self-navigate the environment. The research team specified a speed of 10 km/h for the vehicle AI in order to allow users a sufficient amount of time to observe the environment and identify changes. The gunner position of the HMMWV was an ideal observation point because it is at the center of the vehicle and provides a 360-degree freedom of movement (FOM). A participant's field of view (FOV) in the simulation was 60-degrees horizontally and 38-degrees vertically, a 16:10 aspect ratio.

A plausible operational environment necessitated the selection of pre-existing terrain within VBS2. The research team chose VBS2's "As Samawah (GAA)" terrain because of its similarity to a typical Iraqi urban environment. Although several environments depict Afghanistan in VBS2, the research team determined that the scarcity of objects in these particular terrains did not provide a sufficient amount of "noise" for the scenarios.

A pilot study conducted as part of coursework for Research Methods for Performance Assessment showed that a target every 20–30 seconds resulted in sustained, high-level user performance. A pilot study conducted in the Human Factors of Systems Design course revealed a vigilance decrement by participants occurring between 12–25 minutes. Accounting for these two results, the team limited scenarios for this experiment to 12 minutes, excluding any instruction. The team set the number of changes in a "signal plus noise" scenario to thirty (30).

b. Designing for Vigilance

In her research on vigilance, arousal, and habituation, Jane F. Mackworth described several features to reduce habituation during user task performance (Mackworth,1968, pp. 309–316):

- Background events.
- Presentation of other stimulus.
- Rest pauses.
- Knowledge of Results (KR)

In order to maintain user vigilance, scenario design included several of these features. Scenarios contained three stopping-points for the HMMWV requiring the participant to enter the short keyboard commands “1” and “9” to continue. Designers added triggered sound events throughout the scenarios, activated when the trainee’s vehicle entered pre-defined areas in the VE. Some triggers created ambient noise events such as “Call to Prayer” sounds or traffic noises, while other triggers initiated louder noises, such as a man yelling on a loudspeaker or a truck horn. The team scripted ambient traffic noise including both other road vehicles and helicopters flying over the route. The design did not space targets evenly throughout the route. Instead, the design implemented fluctuation in both actual targets and level of object noise throughout all scenarios. Additionally, the team implemented KR with a “ding” sound that would play if a participant correctly identified a change.

c. Landmarks and Spatial Navigation

Since change detection is notoriously difficult (Rensink, 2002), the researchers implemented various recommended techniques to enhance spatial knowledge acquisition. When designing virtual environments, Darken and Sibert suggest the use of real world design techniques (Darken & Sibert, 1996). These provide an environment that facilitates learning spatial knowledge related tasks. Although Darken and Sibert specifically address navigation, the design team extended these principles to scenario design. Facilitating efficient acquisition of spatial knowledge was the design's ultimate goal. Darken and Sibert suggest organizational principles that should be applied, including dividing the world into "distinct, small parts," organizing these parts using a "simple organizational principle" such as a grid, and providing frequent directional cues (Darken & Sibert, 1996, p.3). In order to maintain spatial awareness throughout virtual environments, they encouraged the use of maps as a fundamental tool. The researchers included a paper overhead map of the scenario area with labeled landmarks at the participant's station (Figure 5). Additionally, the researchers chose a scenario area that could be broken into four distinct parts. Improving a participant's spatial memory performance guided the selection of this particular piece of terrain.

Steck and Mallot advocated the implementation of global and local landmarks in the virtual environment in order to assist navigation in the virtual world (Steck & Mallot, 2000). Their experiment showed that participants encoded landmark information into memory, showing some level of improved spatial memory acquisition. Implementing landmarks in this scenario had the potential to enhance spatial awareness, so the research team chose to include a few unique landmark locations. These landmarks included a bridge, a river, and a Iraqi Police recruiting area.

d. Changes in the Scenarios

Next, the research team determined what changes were appropriate for this study. VBS2 contained hundreds of objects for insertion into scenario design. To maintain operational plausibility, the team chose objects to replicate changes that made sense in the context of a busy Middle Eastern urban environment. Both authors have a total of 36 months in Iraq and Afghanistan. This combat experience informed the selection of changes for implementation in each scenario.

As change detection is a difficult task in any circumstance, the team decided on conspicuous changes that would not be overly difficult to see in the virtual environment. The team did not attempt to hide objects. The design team placed the changed objects a sufficient distance apart from each other to prevent unintentional detections.

An expert team of soldiers with combat patrol experience in Iraq rated each change for a threat value on an ordinal scale of one to five. The researchers presented the experts the before and after screenshots for each change and asked the experts to assign a threat value using the following guidelines:

- Rating: 5 - Immediate action required to react to high threat; followed by report to higher
- Rating: 4 - Significant threat, report to higher and then investigate further with caution
- Rating: 3 - Possible threat or significant activity, report to higher when convenient
- Rating: 2 - Little or no threat but significant enough activity to include in a patrol debrief following the mission
- Rating: 1 - No threat.

The research team averaged all expert ratings and determined the standard deviations. Threat rating determined the rank of each change in the scenario. The team blocked the lowest ten (10) ratings as “low threat,” the highest ten (10) ratings as “high threat,” and the remaining ten (10) ratings as “medium threat.” Developers assigned variable names to changes prior to subject matter expert (SME) evaluations. Variable names had no correlation to SME evaluated threat levels.

Appendix K has a complete list of before and after screen shots of the changes used in each scenario. Appendix I contains the expert rating of each change. Again, the research team warns against interpreting any threat level based on variable names.

Figure 6. Example of baseline environment before change

Figure 7. Example of changed environment (same locations as Figure 6)

#	Variable Name	Before	After	Threat Rating
1	tire_1	Two men	Stack of tires	High
2	burnt_truck_1	SUV in good condition	Burnt SUV	Medium
3	propane_tank_sales_1	Empty garage	Man and boy with propane tanks in garage	Low
4	broken_wall_1	Solid stone wall	Broken wall	Low
5	dirt_pile_1	Empty lot	Bulldozer and dirt pile	Low
6	observer_1	Empty balcony	Man on balcony	Medium
7	vid_camera_1	Man with motorcycle shop	Motorcycles gone, same man with video camera	High
8	running_man_1	Group of men	Man runs away from HMMWV	High
9	ied_box_1	Carpet salesman and a van	Salesmen, carpet and van gone. New box present	Medium
10	ied_supply_man_1	Man selling teddy bears (toys) to children	Children gone, man selling batteries, cell phones, and fuel tanks.	Low
11	odd_drums_1	Nothing	Four (4) colored oil drums	High
12	vbied_van_1	Man selling plants out of a blue van	No people present. Lowered while van, possibly weighted by explosives.	Medium
13	ied_patch_1	Nothing	Small two-foot diameter patch, possibly an implanted IED.	Medium
14	burkha_girl_1	Three females in western dress	Three females in full, black burkha	Low
15	ruined_house_1	House with SUV and three females in western dress	House demolished, several suspicious individuals in the background.	Medium
16	broken_wall_2	Iraqi Police (IP) with IP truck next to a barrier	IP gone, one barrier destroyed, white sacks - possible emplaced explosive	Low
17	bad_trash_pile_1	Several workers and heavy machinery	Workers and machinery gone, new rubble with suspicious barrel extending into the road	Medium
18	broken_wall_ied_1	Solid wall	Wall broken, dark patch indicating possible IED at the site of the break	Medium
19	broken_guardrail_1	Solid unmolested guardrail	Broken guardrail in two separate sections	Medium
20	bad_curb_1	Nothing	Low curb with a broken section indicating possible IED emplacement.	High
21	reporter_1	Group of me picnicing at a roadside café	Reporter and cameraman interviewing men at the roadside café	Medium
22	bad_bag_pile	Two (2) men and four (4) black bags	No men and twelve (12) black bags stacked tightly	High
23	bad_barrels_1	White truck with three barrels, group of six (6) men wandering	Six (6) barrels, no truck, group of men gone, one (1) man observing the barrels from a concealed position	High
24	bad_rubble_1	Large propane tank, no rubble present	Large propane tank burried in a new rubble pile	High
25	broken_fence_no_ip_1	IP HMMWV behind barbed-wire fence	HMMWV gone and half of fence torn down	Low
26	burried_tank_1	Large septic tank on the left side of the road across from IP recruiting station	Septic tank burried on the right side of the road next to the IP recruiting station	High
27	new_containers_1	Large white truck moving in an empty supply yard	Truck is gone, six (6) new large shipping containers in the supply yard	Low
28	poster_wall_1	Unmolested T-Wall barriers	Two (2) large propaganda posters on wall	Low
29	concrete_ied_1	Concrete wall	Broken concrete wall, large concrete block present	High
30	bad_mixer_1	Nothing	Large concrete mixer on the side of the road, parked in an unusual location	Low

Table 2. Scenario #1 change list

#	Variable Name	Before	After	Threat Rating
1	truck_wreck	Small pick-up truck	Large truck wreck	Medium
2	fridge_no_play	Children playing	Children gone, broken refridgerator, and suspicious objects present	High
3	suicide_bomber	Group of five (5) men between appartment buildings	Men gone, man with suspicious vest is visible in the window of one appartment\	High
4	dead_body	Two (2) IP's patrolling on foot, three (3) civilians walking	IP gone, civilians looking at dead body on the ground	High
5	bomb_maker	Motorcycle outside the garage with a man	Man and motorcycle in garrage with a large amount of fuel cans	Low
6	new_rock	Nothing	Suspicious, large rock	High
7	new_van	Empty garage front near IP checkpoint	Blue van parked near IP checkpoint in front of garages	Low
8	boarded_up_shop	Man with computers in garage	Garage closed up with sheet metal with dirt tracks leading out	Medium
9	weird_dudes	Man moving crates and a utility truck	Crates, man and truck gone. Four (4) suspicious men observing the road.	Low
10	press_man	Group of five (5) men wandering around	Men gone, man with press jacket and while press SUV present	Low
11	bomb_car	Group of women in burkha, empty street	Women gone, abandoned white vehicle in the street	High
12	back_to_back_vans	A man standing by a garage with two red vehicles	Red vehicles gone, vans backed up to each other to conceal man's activity in the garage	Medium
13	UN_sacks	Empty garage	Garage full of UN food sacks	Medium
14	ice_cream_dude	Man selling ice cream to children from cart	Children gone, cart gone, man hiding in doorway	Low
15	bad_pile	Busy café front with numerous people	All people gone, large bags in front of café	High
16	new_boxes_no_phone_booth	Phonebooth	Phonebooth gone, boxes stacked by roadside	Medium
17	new_tractor	White car	White car gone, tracktor in its place	Low
18	nobody_ia_cp	IA checkpoint with one (1) HMMWV and two (2) personnel cheking trucks	Checkpoint, HMMWV, and IP gone, trucks moving freely	Low
19	new_car_open_street	Road blocked by barriers	Barriers removed, green car using opened street	Medium
20	broken_wall	T-Wall blocking a side road	One barrier broken, suspicious patch on the ground	Medium
21	turned_truck	Rusted hulk of truck sitting upright on wheels	Rusted truck turned on its side and positioned next to the road	Medium
22	jingle_truck	Empty road	Jingle truck present on the road	Low
23	new_rubble_no_kids	Kids playing in courtyard	Kids gone, courtyard full of metal scraps	Medium
24	wall_truck	Empty side road behind T-Wall barrier	Truck parked directly behind T-Wall barrier	High
25	ip_suicide_bomber	Empty alley across from IP recruiting station	Man with strange vest across from IP recruiting station	High
26	propane_tanks	Man moving shipping boxes into large truck	Man and truck gone, propane tanks placed near road	Medium
27	bad_cart	Donkey and cart with a man	Donkey and man gone, cart full of suspicious objects	High
28	new_cars	Empty supply yard	Four (4) new cars in the supply yard	Low
29	van_bomb	Yellow van parked near the road	Weighted yellow van now in a garage near the road	Low
30	new_barrels	Empty street corner	Three (3) new purple barrels	High

Table 3. Scenario #2 change list

e. In-Simulation Instruction

All scenarios began with in-simulation voiced instruction. The instruction was more significant in the first week and minimal by the second week (Appendix G). The early scenarios emphasized the parameters of the change detection algorithm in detail and with a short test demonstration of the 15-degree left and right azimuth and 50-meter distance limits. Each scenario ended with voiced instruction on expectations for the participant's next session. The final, twelfth, scenario concluded with an in-simulation survey of three questions.

f. In-Simulation Automated Tutorial: the Effect of "Training" vs. "No Training"

Richards et al. stated (2002, p. 223), "Human orientation requires one to remember spatial arrangements of visual landmarks and visualize them from different perspectives." In their experiment, they concluded that subjects eventually develop effective strategies for remembering the spatial arrangement of objects. They also found that teaching these strategies in advance greatly improved performance at remembering the spatial arrangement of objects. Additionally, these strategies worked as an equalizer for those less apt to quickly adapt to the virtual environment. Just as Orvis et al. (2010) concluded, pretraining provided less experienced users with a method to improve performance.

Figure 8. Screenshot of in-simulation tutorial

For this thesis, the “training” group received short instruction within the same virtual environment. The team created the tutorial on a different part of the As Samawah terrain. Prior to the first session and the seventh session (Week 1 and Week 3) the “training” group experienced the short tutorial. The “no training” group received no tutorial instruction. The instructional scenario in week 1 was different from the instructional scenario in week 3. The week 1 training focused on basic change detection strategies in the virtual environment, while the session in week 3 taught some more advanced techniques for success. The research team designed each training session just like the experimental scenarios; however, the team used different terrain and different changes from the “signal plus noise” scenarios. Each instructional scenario lasted approximately six (6) minutes. Participants in this group observed a example baseline scenario with voiceover instruction. Then, they immediately viewed a changed, signal plus noise, environment with additional voiceover instruction (Appendix G, Subsection B).

4. User Interface

The team's objective for the interface was one that did not detract from the learning experience. Therefore, the team chose a minimalist approach for input requirements. There were four primary interface requirements:

- A visual presentation of the environment (output)
- A auditory presentation of the environment (output)
- A method for participants to manipulate their view (input)
- A method for participants to indicate they detected a change (input)

Due to the desire for the trainer to be distributable, the team chose to use a standard monitor and headphones as output devices to participants. These devices were simple, cheap, and dominated usability considerations when compared to head-mounted displays or surround sound.

For view control, the design team tested several options. As part of OA3401, Human Factors in System Design, course requirements, the research team tested the effectiveness of two input devices. These devices were the common personal computer (PC) mouse and a head-mounted control device called the TrackIR by Naturalpoint. The TrackIR allowed six degrees of freedom (6DOF) head movement to manipulate a participant's view of the virtual world. The results of the experiment indicated that the mouse presented less of a learning curve for users. Even though the TrackIR was more natural and closely modeled the kind of head movements required to observe real environments, the TrackIR's learning curve was steep. It also had the potential to detract from the task of learning to detect change. The design team chose to use a large, wireless mouse with a special low friction mouse pad in order to provide a smooth mouse surface that would not distract the user while controlling the viewpoint in the simulation.

Figure 9. Experimental interfaces

Finally, the research team explored various methods for getting input on confidence and detections from participants. During the same experiment in the Human Factors in Systems Design course, the research team required a user to verbalize their detections. This approach was effective, but it placed a heavy burden on both the participant and observer to verify detections. An automated solution was necessary.

During the experiment conducted as part of Research Methods for Performance Assessment, the team scripted a method in VBS2 that linked keyboard inputs to user decisions. Text file outputs for analysis validated the input method, and the team decided that using the keyboard for input was best. Additionally, keyboards supported the central tenet of being distributable to the entire Army.

5. Scoring

The team bound the "V," "B" and "N" keys to high, medium and low confidence selections. VBS2 scripts enabled the key binding, and the team re-labeled the keys "H," "M" and "L" as representations for high, medium, or low confidence levels, respectively. The research team instructed the participants to press the key corresponding with the participant's confidence that a change was in their field of view. A key press executed the appropriate script, registered a button press, and then checked for a listed change using the VBS2 *isLookingAt* command script. The method received the participant's current viewpoint as input, and the algorithm compared any objects in the participant's field of view with an array of known changes. The array contained variable names for all objects designated as changes in each scenario. VBS2 scored a correct detection as a "hit," if an object in the array was within a 15-degree arc and closer than 50 meters. These scripts scored each key press a "hit" or "false alarm" at that confidence level in the text file output. VBS2 scripts logged any key press by a participant, whether or not a change was present.

B. PARTICIPANTS

1. Recruiting

Research participants were recruited from the student body at the Naval Postgraduate School (NPS). The research team recruited participants on a voluntary basis using an Institutional Review Board (IRB) approved invitation e-mail. Screening criteria for participants included three factors. Because testing scenarios depicted a neighborhood similar to ones in Iraq or Afghanistan, participants could have no history of Post-Traumatic Stress (PTS). Due to a first-person perspective in VBS2, participants could have no history of simulator sickness or motion sickness. In order to eliminate possible confounds due to vision differences, participants needed to have vision correctable to 20/20.

Sixteen volunteers passed all screening criteria. One volunteer began the experiment, but did not complete the study for personal reasons. The fifteen participants completing the study came from all branches of service and included two international students. All fifteen volunteers were males between the ages of 28 and 41 years-old. The average age was 34. The team made no conscious decision to exclude female participants. In fact, females participated in pilot studies conducted as part of coursework at NPS and did quite well at change detection tasks. However, no females volunteered for this experiment.

Catgory	Specific Category	Total	Training	No Training
Branch of Service	Navy	6	3	3
	Army	3	2	1
	Marines	2	0	2
	Air Force	2	1	1
	International	2	1	1
Rank	O4	8	4	4
	O3	6	3	3
	O2	1	0	1
Play Video Games	Yes	9	4	5
	No	6	3	3
Gamers	Yes	7	2	5
	No	8	5	3
Ground Combat Experience	Yes	3	2	1
	No	12	5	7

Table 4. Participant Demographic Data

2. Blocking

The research team randomly assigned participants between two experimental groups. A control group received no training in the virtual environment. The experimental group received a brief, three-minute (3) change detection tutorial every other week. The research team blocked participants by the categories listed in Table 2. The characteristics most important were branch-of-service, rank, and video game experience. The research team determined that video game experience was more important than whether or not a participant considered himself a gamer. The term gamer was largely subjective while playing video games was a nominal yes or no. Many participants commented that they did not know what constituted being a "gamer." They were not all satisfied with Orvis' definition mentioned previously in this report.

For the remainder of this thesis, the terms "no training" and "training" describe the two experimental groups. These titles are easy to remember and adequately depict the difference between the two.

C. PROCEDURES

1. Before the Experiment

Before beginning the experiment, each participant received an e-mail with instructions based on their experimental group and a map of the virtual environment (Appendix A contains copies of these materials). The research team scheduled the first three experimental sessions for week 1 prior to beginning any experimentation. This scheduling technique ensured that participants completed all three sessions with approximately 24-hours between sessions, on average (Appendix H contains the exact times between each participant's training sessions).

Prior to beginning Session#1 of the experiment, participants read and signed the IRB-approved Informed Consent Form (Appendix D). They also completed a brief demographic survey (Appendix E) used to assign participants to groups and determine some key characteristics for analysis of the results. One of the survey questions asked participants if they thought that computer-based simulation training was an effective training tool for tactical training. Figure 10 outlines the results of this survey.

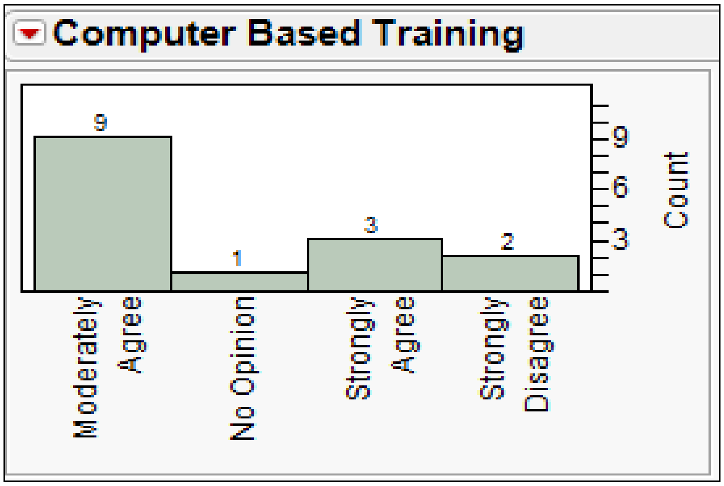


Figure 10. Participant opinions of computer simulation based training

The computer based simulation-training question identified any pre-existing biases participants might have about the training they received in VBS2. An overwhelming majority agreed, in varying degrees, that computer-based simulation training was an effective method.

2. During the Experiment

The TRADOC Analysis Center – Monterey (TRAC-MTRY) housed the experimental cubicle in their combat models lab. When a participant arrived for one of their twelve, 15-minute sessions, the research team escorted them into the testing cubicle. The team allowed participants a moment to get comfortable in the chair, don the headphones, position their hands on the keyboard, and grasp the mouse. The simulation began when a participant indicated they were ready. Each session began with in-simulation instructions specific to that day (Appendix G).

Each week followed the same sequence of three sessions. The first session exposed a participant to the "baseline" environment. The research team explicitly told users to examine the environment so that they could properly identify changes in future scenarios. The second session was another exposure to the same “baseline” scenario; but the research team concealed the fact that it was the “baseline” scenario. The team instructed participants to look for changes. Finally, the third and final session of each week presented one of the two “change” scenarios.

WEEK	DAY 1	DAY 2	DAY 3
1	Baseline, explicit Tutorial for "Training" group	Baseline, concealed	Change 1
2	Baseline, explicit	Baseline, concealed	Change 2
3	Baseline, explicit Tutorial for "Training" group	Baseline, concealed	Change 1
4	Baseline, explicit	Baseline, concealed	Change 2

Table 5. Treatment Plan for Participants

During a given scenario, each participant scanned the road, both left and right to learn the environment or detect changes in the environment. If a participant thought they discovered a change, they moved the mouse cursor within 15 degrees and 50 meters of the change and pressed a confidence key on the keyboard. If they were correct, they received an audible tone, knowledge of results (KR). If they were incorrect, they received no KR.

The simulation consisted of four right-hand turns. The participant pressed the “1” and then the “9” key to continue on the waypoint. Pressing waypoint buttons was a secondary task to keep the user engaged in the scenario and keep the simulation on track. The simulation ended when the HMMWV reached the end of the fourth leg of the patrol route.

3. After the Experiment

At the end of each session, a participant removed the headphones, stood up, and the research team escorted them out of the testing area. A member of the team downloaded the data from the participant’s session and Prepared the simulation for the next participant.

After the final session, participants answered a three-question survey in order to assess their opinion of the training and gain insights into the effectiveness of the experiment. The research team thanked participants for the four weeks of dedication to the process, and then they escorted them from the testing area.

D. MATERIALS

1. Hardware

In order to minimize the negative effects of virtual 3D graphics associated with low frame rates and graphical artifacts, a high-end desktop computer powered the experiment. It contained the following specifications:

- Intel I7 930 @4.0 GHz CPU
- G.SKILL Ripjaws Series 12GB (6 x 2GB) 240-Pin DDR3 SDRAM DDR3 2000
- 2x EVGA Superclocked Nvidia GTX 480 GPU PCI-Express cards (SLI)
- Western Digital VelociRaptor 600GB 10000 RPM 32MB Cache SATA 6.0Gb/s HDD
- Microsoft SideWinder X8 Black 12 Buttons Tilt Wheel 2.4GHz Wireless Gaming Mouse
- Logitech Illuminated Keyboard 104-key
- Plantronics Gamecom 777 Gaming Headphones

Although this is a high-end desktop system and not readily deployable, it resembles what will be available with future distributable technologies.

Participants used five keys on a standard 104-key PC keyboard during the experiment. The post-experiment survey required two additional keys. The research team labeled seven keys with masking tape so that the participants could easily identify the correct keys. Two keys commanded the vehicle AI to proceed to the next waypoint. Three keys correlated to confidence levels at identifying changes. The last two keys logged yes and no input for the post-experiment survey.

Figure 11. Close up of the keyboard configuration

The team decided to utilize a very large screen monitor, 28-inches diagonally, for a more immersive and comfortable environment. Noise-cancelling gaming headphones increased immersion for the audio modality. These headphones also blocked out other noise in the lab and allowed participants to focus on the task of change detection. All participants tested on the same hardware, with the labeled 104-key keyboard, headphones, and mouse. Participants sat with their face approximately 24 inches from the screen throughout the experiment. Due to family emergencies, two participants used a slightly smaller 26-inch display for one session each.

2. Data Collection Systems and Software

VBS2 wrote participant data to several text files during the simulation using the external script files. The research gathered the following key points of data anytime a participant pressed a key to attempt to identify a change:

- direction of head relative to the vehicle in degrees
- simulation time in hundredths of a second
- confidence level key pressed (“H,” “M,” or “L”)

VBS2 copied this data to a text file called “clicked.” Additionally, any time a participant pressed a button to identify a change, the scripts incremented tally variables recording the number of clicks and confidence level. If a change existed, when and where the participant pressed a confidence key, VBS2 incremented the correct detection tally variable. If a participant correctly identified a change, the scripts wrote a line to the text file named “targetsFound.” This line recorded:

- the target name
- the simulation time
- the relative head direction of the participant
- the confidence level key pressed.

By subtracting the number of detections form total clicks, the research team obtained the total number of false alarms per session. During the second session each week, the false alarms were the total number of clicks, since these were “noise only” iterations.

At the end of the scenario, VBS2 wrote the tally variables’ values to a text file named “targetFinalScore.” To facilitate further analysis of participant behavior, the VBS2 scripts copied a participant’s relative head direction to the vehicle to the “headDirection” text file every 200 milliseconds.

3. Surveys

Prior to testing, each participant filled out a pre-test, demographic survey. This survey identified specific characteristics needed for blocking and randomly assigning participants into experimental groups (Appendix E).

Following the final experimental session, each participant answered a three-question automated survey. There were two versions of the survey, one for each of the experimental groups. Participants in the “training” (experimental) group answered the following questions in the simulation using labeled keys:

- Question 1: “After completing these 12 sessions of Change Detection training, do you feel that you would perform better at tasks related to identifying change in the real world?”
- Question 2: “Do you feel that the tutorial lessons you received at the start of Weeks 1 and 7 helped you better identify change?”
- Question 3: “Do you feel it was easier to identify changes which indicated a high level threat versus changes that suggested little or no threat?”

Participants in the “no training” (control) group answered the following questions in the simulation using labeled keys:

- Question 1: “After completing these 12 sessions of Change Detection training, do you feel that you would perform better at tasks related to identifying change in the real world?”
- Question 2: “Do you feel that you would have performed better had you received instructional training as part of this experience?”
- Question 3: “Do you feel it was easier to identify changes which indicated a high level threat versus changes that suggested little or no threat?”

IV. RESULTS AND DISCUSSION

A. DEMOGRAPHICS

Participants in this experiment came from the student body at NPS. Sixteen volunteers began the study; however, only fifteen completed the experiment. All participants were male between the ages of 28–41. The average age was 34 years old with a standard deviation of 4.6 years.

Catgory	Specific Category	Total	Training	No Training
Branch of Service	Navy	6	3	3
	Army	3	2	1
	Marines	2	0	2
	Air Force	2	1	1
	International	2	1	1
Rank	O4	8	4	4
	O3	6	3	3
	O2	1	0	1
Play Video Games	Yes	9	4	5
	No	6	3	3
Gamers	Yes	7	2	5
	No	8	5	3
Ground Combat Experience	Yes	3	2	1
	No	12	5	7

Table 6. Demographic data by group

Table 6 shows the totals for each demographic category and the breakdown of participants for each experimental group. The group labeled "Training" was the experimental group that received the short virtual tutor prior to Sessions 3 and 9. The group labeled "No Training" received no tutorials for change detection.

B. ANALYSIS OF CORRECT DETECTIONS (HITS)

When a participant detected a change in the virtual environment, they pressed a key corresponding with high, medium, or low confidence. When the participant pressed any confidence key, a VBS2 script logged the keystroke. The first output of interest to the research team was the number of correct detections by session. Sessions 3, 6, 9, and 12 contained actual changes. Figure 12 shows the improvement across all groups at detecting changes in those sessions.

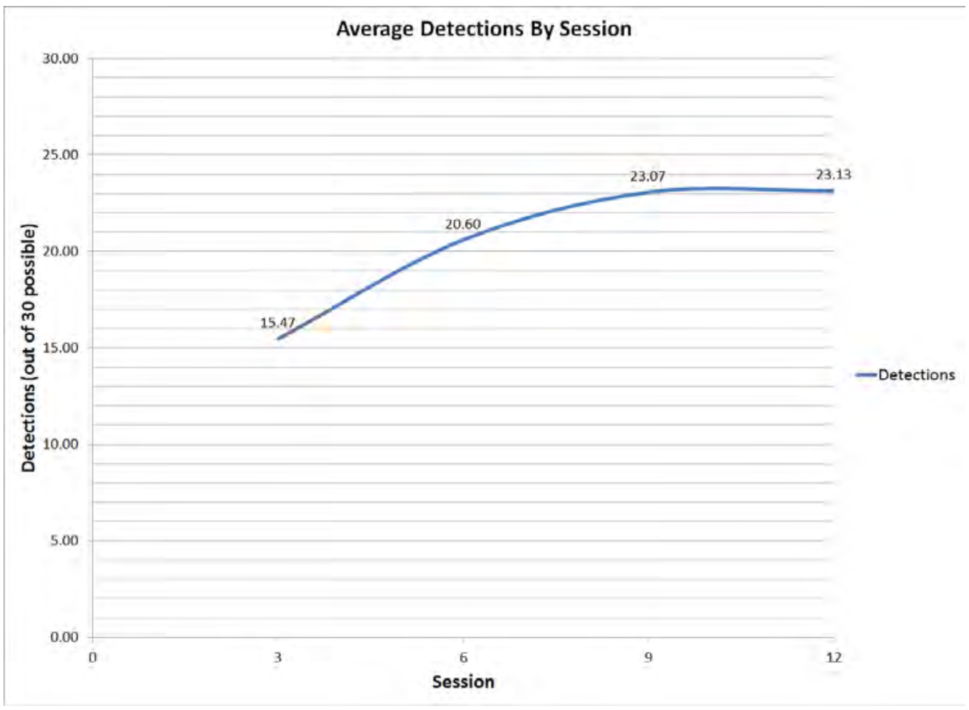


Figure 12. Mean detections by session

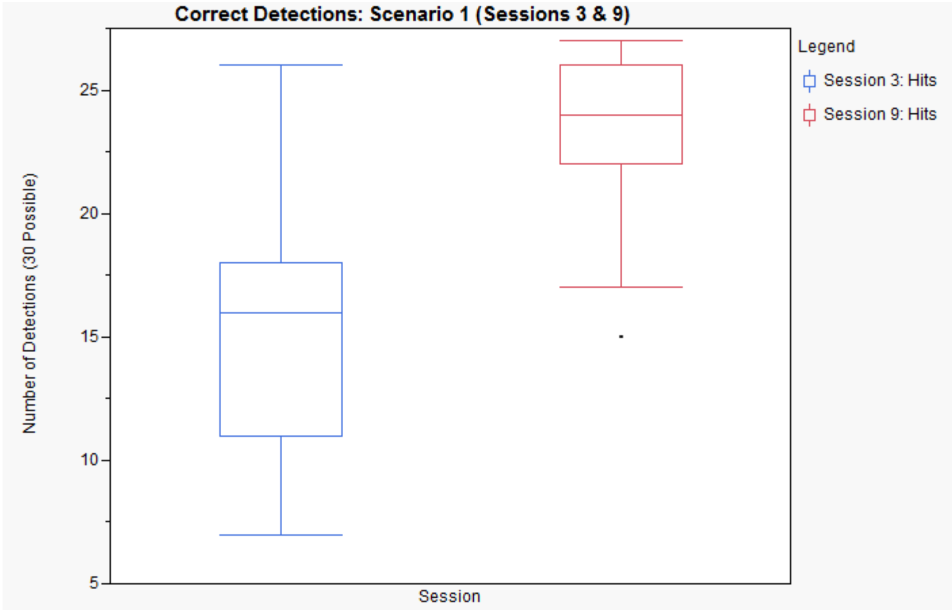


Figure 13. Correct detections (hits) for all participants, Scenario 1

In addition to looking at the mean detections for all participants across all sessions, the research team also analyzed the number of correct detections within the two scenarios for all participants. Figure 13 shows the improvement for all participants from Session 3 to Session 9. These two sessions utilized Scenario 1.

Session 9: Hits	23.0667	t-Ratio	5.363804
Session 3: Hits	15.4667	DF	14
Mean Difference	7.6	Prob > |t|	<.0001*
Std Error	1.4169	Prob > t	<.0001*
Upper 95%	10.639	Prob < t	1.0000
Lower 95%	4.56104		
N	15		
Correlation	0.27217		

Table 7. JMP output for correct detections, all participants, Scenario 1

Table 7 shows the JMP output for the paired-t test conducted on this data. The average improvement for all participants was an increase in 7.6 correct detections out of thirty (30) possible changes. This improvement occurred across Session 3 to Session 9 with a standard deviation of 1.42. This had a p-value less than 0.0001.

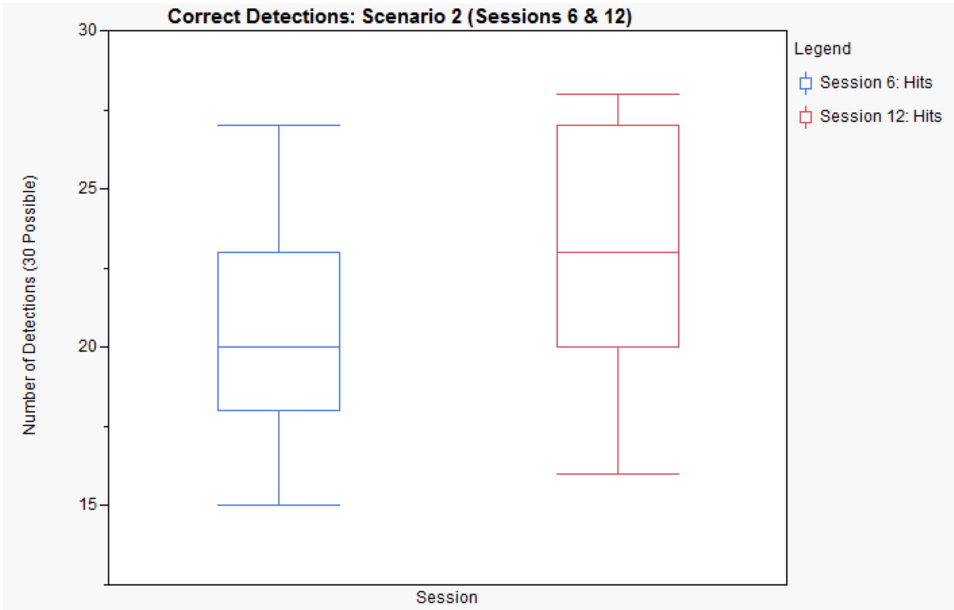


Figure 14. Correct detections (hits) for all participants, Scenario 2

Conducting the same analysis of Scenario 2, the research team analyzed the number of correct detections within Scenario 2 sessions for all participants. Figure 14 shows the improvement for all participants from Session 6 to Session 12. These two sessions utilized Scenario 2.

Session 12: Hits	23.1333	t-Ratio	5.104072
Session 6: Hits	20.6	DF	14
Mean Difference	2.53333	Prob > |t|	0.0002*
Std Error	0.49634	Prob > t	<.0001*
Upper 95%	3.59787	Prob < t	0.9999
Lower 95%	1.4688		
N	15		
Correlation	0.84881		

Table 8. JMP output for correct detections, all participants, Scenario 2

Table 8 shows the JMP output for the paired-t test conducted on this data. The average participant improved by 2.5 correct detections out of a possible thirty (30) changes. This improvement occurred from Session 6 to Session 12 with a standard deviation of 0.5. While this data reveals a smaller degree of improvement, it also contains less variance. This could indicate that participants were all reaching a more stable ability to detect changes in their environment; however, due to the small sample size, results did not support this assumption.

Finally, the team analyzed the correct detections over both scenarios and all four sessions. Displaying the boxplots in sequence for all four sessions looks similar to Figure 12 that illustrated the average number of detections as a smooth curve over time. The boxplots in Figure 15 provide some indication of the variance within each session.

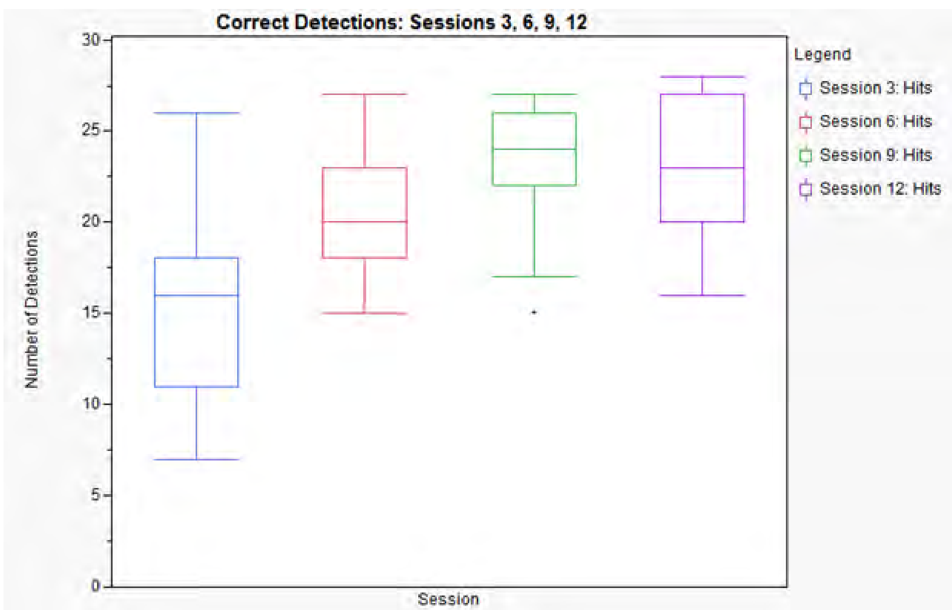


Figure 15. Correct detections (hits) for all participants, all sessions

Figure 15 revealed a steady increase in detections and decrease in variance over time. The exception to this trend was Session 12, the final session, where the variance increased again. The research team attributed this revelation to participants "letting down" after four weeks of testing; however, there is no data to support this assumption. This also suggests that nine (9) sessions are enough because the participants display little improvement after the ninth session. Of note, some participants anecdotally stated that the length of the experiment started to wear them down.

Oneway Anova

Summary of Fit

Rsquare	0.392483
Adj Rsquare	0.359938
Root Mean Square Error	4.013371
Mean of Response	20.56667
Observations (or Sum Wgts)	60

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Session	3	582.7333	194.244	12.0595	<.0001*
Error	56	902.0000	16.107		
C. Total	59	1484.7333			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
3	15	15.4667	1.0362	13.391	17.543
6	15	20.6000	1.0362	18.524	22.676
9	15	23.0667	1.0362	20.991	25.143
12	15	23.1333	1.0362	21.057	25.209

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
3	15	15.4667	5.31664	1.3728	12.522	18.411
6	15	20.6000	3.43927	0.8880	18.695	22.505
9	15	23.0667	3.43234	0.8862	21.166	24.967
12	15	23.1333	3.54293	0.9148	21.171	25.095

Table 9. JMP ANOVA for correct detections over all sessions

Table 9 shows the statistical output for the analysis of variance (ANOVA) for Sessions 3, 6, 9, and 12. The resulting p-value less than 0.0001 indicates there is statistically significant improvement, as shown by the paired t-tests (Table 7 and Table 8) for each scenario. Appendix H contains comprehensive data in JMP used for these tests.

The results of this research supported the research hypothesis predicting detection rates would increase over time. In fact, the research team expected a result exactly like the one in this experiment. The steep increase in detections early in the experiment followed by asymptotic performance at the end of the experiment resembled a traditional learning curve.

Perhaps the only unexpected outcome in the analysis of correct detections was how significantly participants improved over the first two-weeks. The research team assumed that participants would naturally get better from week-to-week; however, the magnitude of improvement was a welcome surprise.

C. ANALYSIS OF FALSE ALARMS (FA)

Each week, the research team collected false alarm data during two sessions. The simulation recorded false alarm data for the second session each week. During that session, the in-simulation voice-over instructed a participant to search for changes in the environment. The second sessions each week were Sessions 2, 5, 8, and 11. Unbeknownst to participants, there were no changes to the environment in any of those sessions. This data provided an indication of a participant's propensity to press a button for change and provided the classic Signal Detection Theory case where there is noise without a signal. This data also provided insights into bias as described by SDT. The second time the research team collected data on false alarm rates was during the third session each week in which there were signals among the noise, as previously described for correct detections.

As was the case with correct detections, when a participant thought they detected a change in the virtual environment, they pressed a key corresponding with high, medium, or low confidence. VBS2 scripts logged the keystroke. The first output of interest to the research team was the number of false alarms when there were no signals in the noise. Sessions 2, 5, 8, and 11 contained no changes (signals). Figure 16 shows a sharp decay of false alarm averages across all participants during these sessions.

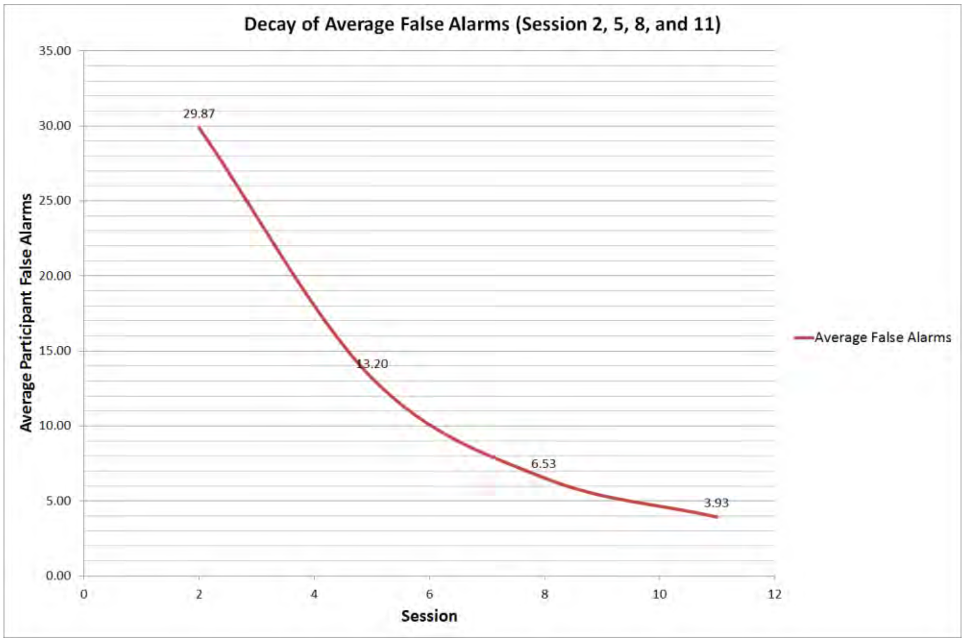


Figure 16. Mean false alarms by “Noise Only” sessions

Next, the research team looked at the false alarms for all sessions. This included the sessions with and without the presence of signals in the noise. Recall that Sessions 2, 5, 8, and 11 were noise only. Sessions 3, 6, 9, and 12 contained signals, or changes, in the noise. Figure 17 depicts false alarms across all sessions

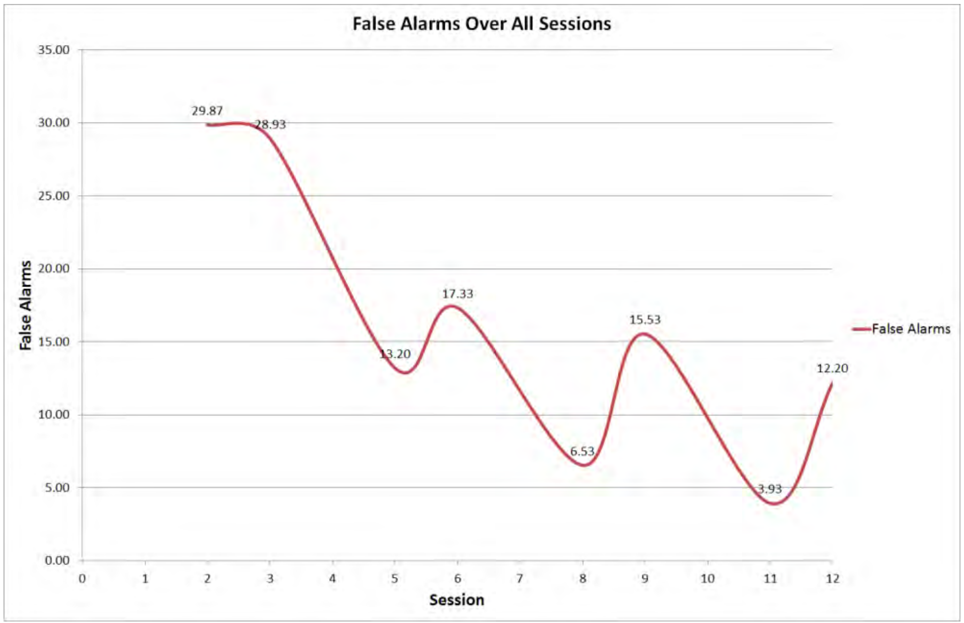


Figure 17. False alarms over all sessions

The results showed a tendency for more false alarms when there are signals in the environment. Some of these false alarms manifested themselves in the data due to participants who pressed a button to detect a change when the change was still outside the allowable 15-degree and 50-meter range from the vehicle. Other false alarms registered due to a participant's inaccuracy moving the mouse over a target. In both these cases, a participant detected the change, but due to participant error, VBS2 registered a false alarm. The research team tried to account for these errors as much as possible; however, there was no objective way to determine user error versus an actual false alarm. Granted, these errors accounted for only a portion of false alarms per session; however, it makes the second session of each week a more accurate measure of false alarms. During those sessions, any press of a button to denote a change in the environment was an actual false alarm. This method also aligns itself with the more traditional Signal Detection Theory methods of testing where the environment is not continuous, but rather, a single instance contains a signal or it does not.

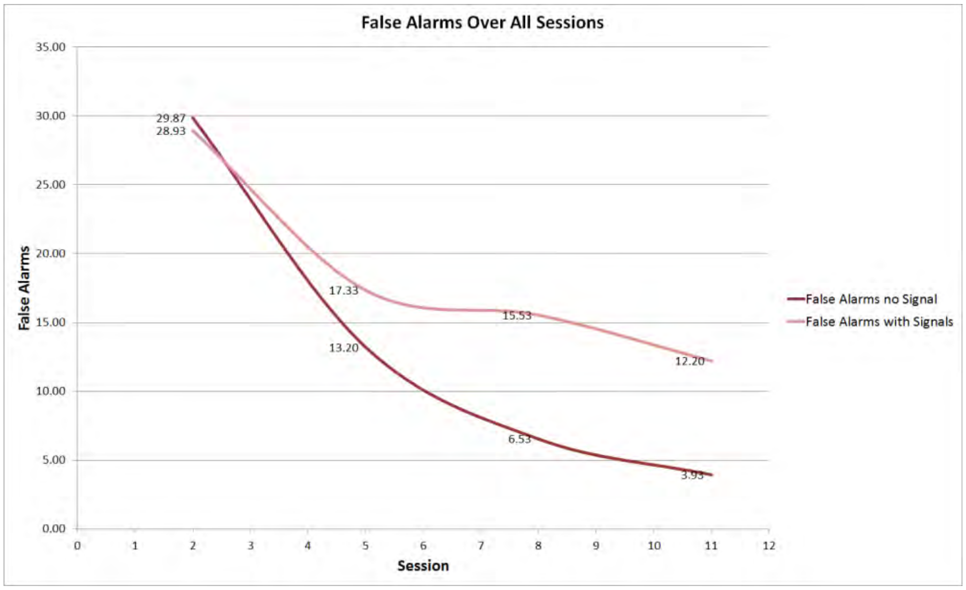


Figure 18. False alarms signal or no signal present

Figure 18 separates the fluctuating curve of Figure 17 into two distinct curves. These two curves distinguish between false alarms occurring in sessions with noise only and sessions with signals-plus-noise. In both cases, the false alarm rate continues to decrease over time, even with the additional false alarms in the sessions with signals in the noise

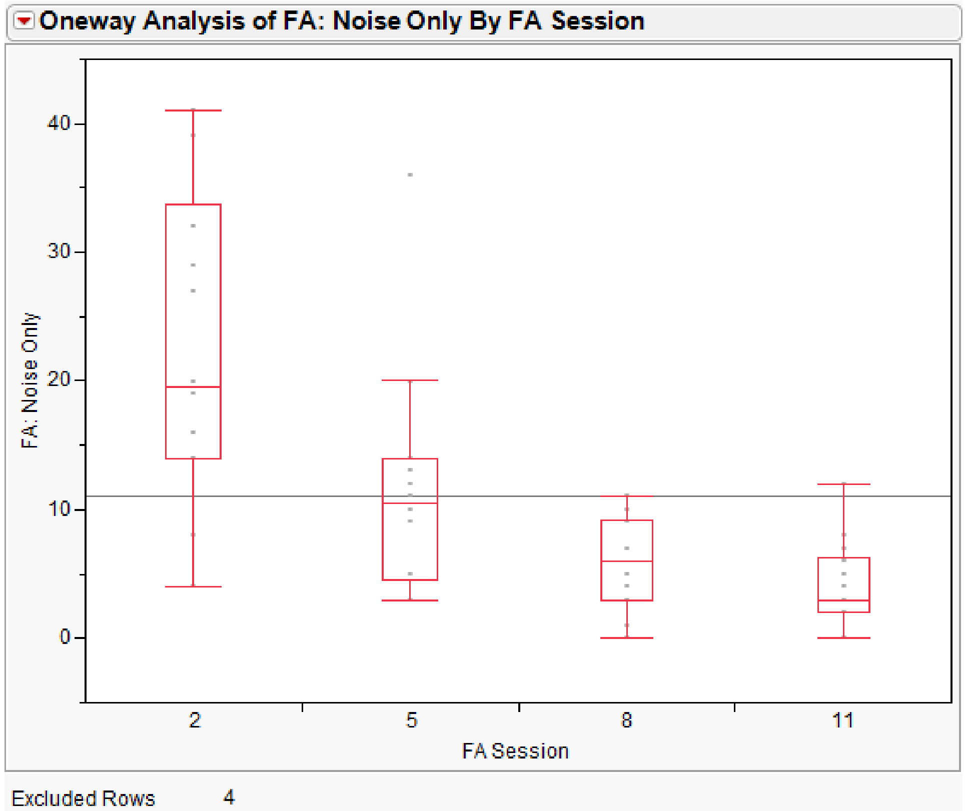


Figure 19. Boxplot of false alarms, noise only sessions

One participant had 129 false alarms in Session 3. Figure 19 excludes this participant's data. Of note, even with that outlier, the result was significant; however, excluding his data actually increased the significance of the result. The boxplots in Figure 19 showed the significant decrease in participant average false alarms over time. The box plots also demonstrated the continual decrease in variance of false alarms over time.

Oneway Anova

Summary of Fit

Rsquare	0.490455
Adj Rsquare	0.461058
Root Mean Square Error	7.718609
Mean of Response	11.03571
Observations (or Sum Wgts)	56

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
FA Session	3	2981.9286	993.976	16.6839	<.0001*
Error	52	3098.0000	59.577		
C. Total	55	6079.9286			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
2	14	22.7143	2.0629	18.57	26.854
5	14	11.5714	2.0629	7.43	15.711
8	14	5.8571	2.0629	1.72	9.997
11	14	4.0000	2.0629	-0.14	8.139

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
2	14	22.7143	11.8933	3.1786	15.847	29.581
5	14	11.5714	8.5998	2.2984	6.606	16.537
8	14	5.8571	3.4386	0.9190	3.872	7.843
11	14	4.0000	3.3282	0.8895	2.078	5.922

Table 10. JMP ANOVA output for FA during noise only sessions (N=14)

Table 10 shows the statistical output for the ANOVA for Sessions 2, 5, 8, and 11. The resulting p-value less than 0.0001 demonstrates there is statistically significant reduction in false alarms over time. Appendix H contains comprehensive tables of the JMP data used for these tests.

Oneway Anova

Summary of Fit

Rsquare	0.296853
Adj Rsquare	0.259184
Root Mean Square Error	16.08837
Mean of Response	13.38333
Observations (or Sum Wgts)	60

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
FA Session	3	6119.383	2039.79	7.8807	0.0002*
Error	56	14494.800	258.84		
C. Total	59	20614.183			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
2	15	29.8667	4.1540	21.55	38.188
5	15	13.2000	4.1540	4.88	21.521
8	15	6.5333	4.1540	-1.79	14.855
11	15	3.9333	4.1540	-4.39	12.255

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
2	15	29.8667	29.9782	7.7403	13.265	46.468
5	15	13.2000	10.4143	2.6890	7.433	18.967
8	15	6.5333	4.2235	1.0905	4.194	8.872
11	15	3.9333	3.2175	0.8308	2.152	5.715

Table 11. JMP ANOVA for FA during noise only sessions (N=15)

Table 11 shows the statistical output for the ANOVA for Sessions 2, 5, 8, and 11 using all participants' data (N=15). The resulting p-value is 0.0002. There is statistically significant reduction in false alarms over time. By excluding one outlier (participant), the variance decreases from 29.97 to 11.89 for session 2.

Participant data clearly showed a sharp decay in false alarm rates over time. This result supported the hypothesis that false alarms would decrease over time. Due to extensive reading on Signal Detection Theory literature, the research team had less confidence in this prediction than the prediction about increased detection rates. The literature often spoke of bias, an individual's propensity to say there is (or is not) a signal among noise more than 50% of the time (Proctor et al., 2008). The research team suspected that if participants began to detect more changes, they might also record more false alarms. As it turned out, the false alarm rates decreased as detection rates increased. This result was significant, and it clearly showed the participant's sensitivity to changes. The resulting sensitivity represented a "best-case" scenario, exhibiting a precise capability that any change detection trainer should possess.

D. CORRECT DETECTIONS VS. FALSE ALARMS

One of the hypotheses for this study sought to examine if it was possible for detection rates to increase while simultaneously decreasing false alarm rates. A participant could potentially increase both rates, indicating that the training did not improve sensitivity to changes in the environment. Figure 20 illustrates the percentage of key presses, or clicks, expended for correct detections versus false alarms during the sessions with signals plus noise.

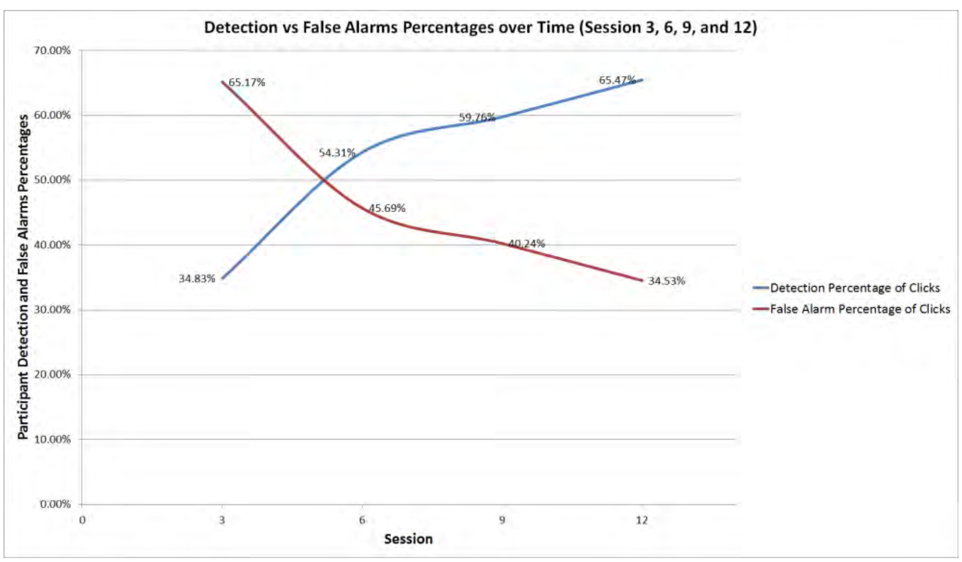


Figure 20. Detections versus false alarm percentages over time

There would be an even greater distance between the percentage of false alarms and correct detections if the research team had developed a better method to discern between an actual false alarm and human error in range estimation. The previous section of this report addressed this issue; however, Figure 20 showed the research team that there could have been a larger gap, if an improved measure for false alarms existed during signal plus noise trials.

The team determined during deliberate analysis of the virtual environment that there were approximately 5000 potential locations for a change (Appendix L). This discrete number of locations allowed the team to apply classic SDT metrics in a continuous virtual environment. During a signal-plus-noise trial in SDT, previous work classified a participant's response as a hit or miss. Traditionally, signal-plus-noise trails do not produce false alarm responses. Discretizing the environment enabled the application of SDT metrics to a continuous environment.

Small sample size and a single training evolution per participant make it difficult to construct meaningful receiver operating characteristic (ROC) curves for this experiment. While Figure 20 is not a traditional SDT sensitivity (d') analysis or ROC curve, the research team believes that it sufficiently demonstrates the sensitivity of the training, even with any participant's unintentional false alarm clicks.

E. CONFIDENCE

Measuring a participant's confidence over time was the next area of interest for the research team. As mentioned previously, every time a participant thought they detected a change in their environment, a corresponding key press indicated their level of confidence. This section of the report analyzed confidence over time, specifically, confidence at correctly detecting changes in the environment. The research team investigated the participants as a whole and at each group to determine if participants became more confident in their ability as the experiment progressed.

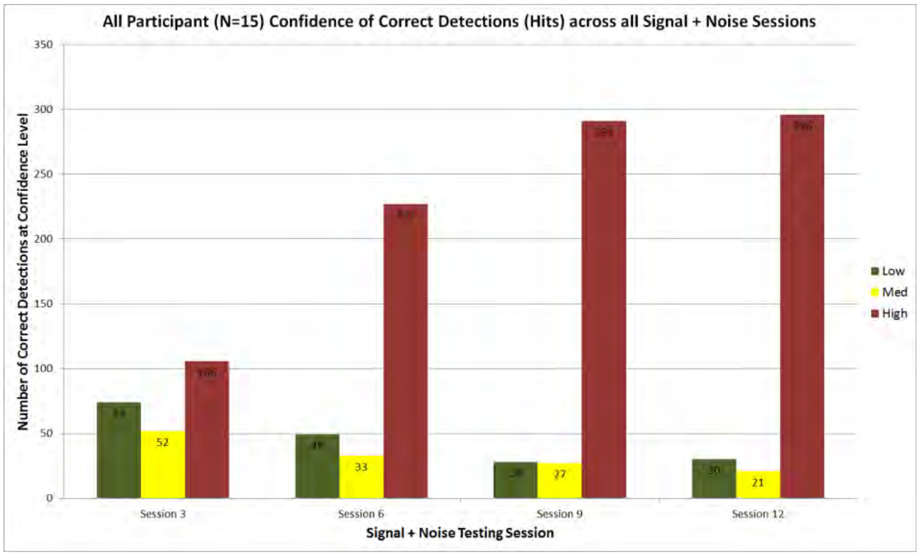


Figure 21. Confidence levels for all participants, signal + noise

Figure 21 clearly shows a large number of high confidence detections by Session 12 when compared to the number of high confidence detections in Session 3.

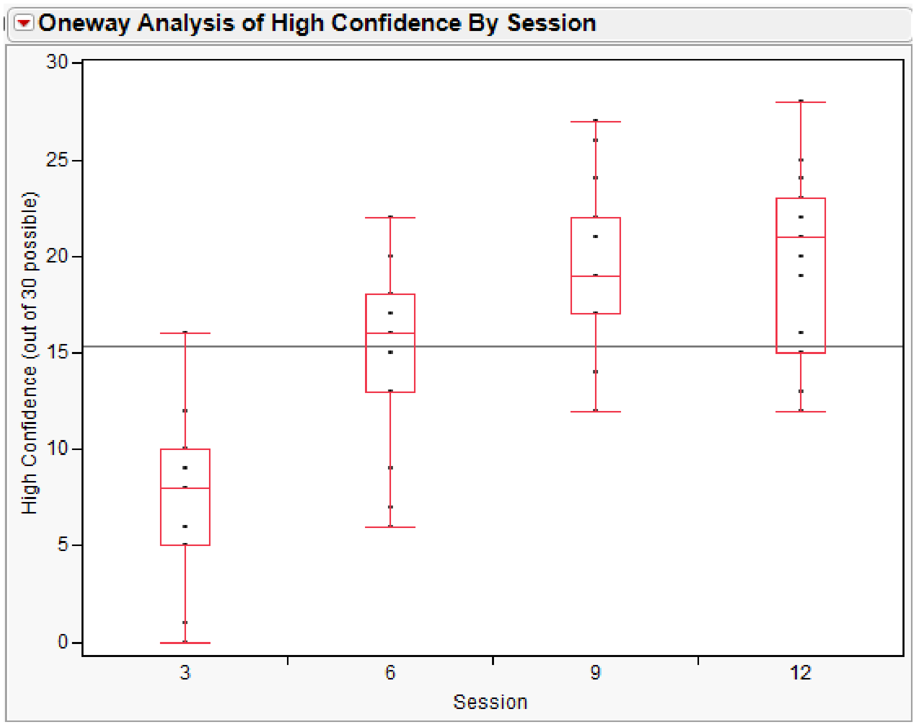


Figure 22. Boxplot for confidence by session (N=15)

Oneway Anova

Summary of Fit

Rsquare	0.561158
Adj Rsquare	0.537648
Root Mean Square Error	4.673634
Mean of Response	15.33333
Observations (or Sum Wgts)	60

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Session	3	1564.1333	521.378	23.8695	<.0001*
Error	56	1223.2000	21.843		
C. Total	59	2787.3333			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
3	15	7.0667	1.2067	4.649	9.484
6	15	15.1333	1.2067	12.716	17.551
9	15	19.4000	1.2067	16.983	21.817
12	15	19.7333	1.2067	17.316	22.151

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
3	15	7.0667	4.47958	1.1566	4.586	9.547
6	15	15.1333	4.77892	1.2339	12.487	17.780
9	15	19.4000	4.37199	1.1288	16.979	21.821
12	15	19.7333	5.03511	1.3001	16.945	22.522

Table 12. JMP output on ANOVA for confidence by session (N=15)

Only one (1) participant never used the “low” or “medium” confidence key in any session. For the final two (2) sessions, two (2) participants used only the “high” confidence key, and two (2) other participants used only the “high” confidence key exclusively during one (1) session.

Oneway Anova

Summary of Fit

Rsquare	0.54233
Adj Rsquare	0.512481
Root Mean Square Error	4.520705
Mean of Response	14.28
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Session	3	1113.9883	371.329	18.1697	<.0001*
Error	46	940.0917	20.437		
C. Total	49	2054.0800			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
3	13	6.6923	1.2538	4.169	9.216
6	14	14.9286	1.2082	12.497	17.361
9	11	17.4545	1.3630	14.711	20.198
12	12	18.8333	1.3050	16.206	21.460

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
3	13	6.6923	4.71495	1.3077	3.843	9.542
6	14	14.9286	4.89056	1.3071	12.105	17.752
9	11	17.4545	3.11010	0.9377	15.365	19.544
12	12	18.8333	4.91442	1.4187	15.711	21.956

Table 13. ANOVA for confidence by session, excluding “high” only responses

Table 12 shows the ANOVA for confidence using all 15 participants’ responses. There is a significant difference between at least two of the sessions with a p-value of 0.0001. Excluding the participants who only used the “high” confidence key, Table 13 shows the result is still significant. The F-ratio only drops slightly from 23.8 down to 18.1. This is still has a p-value below 0.0001. Appendix I shows a complete breakdown of confidence key usage by participant for each session.

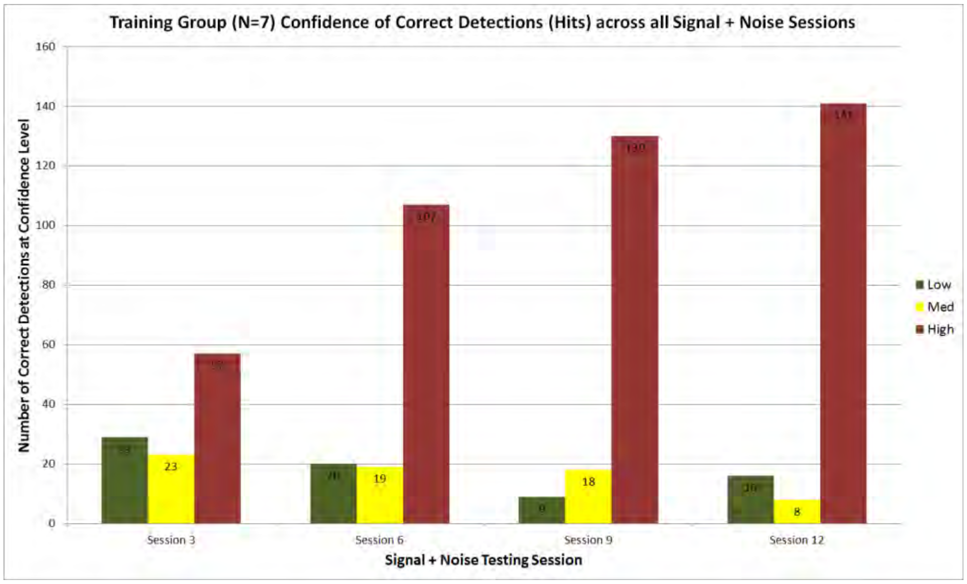


Figure 23. Confidence levels for “Training” group, signal + noise

Confidence among participants in the “Training” group continued to rise throughout the experiment as shown in Figure 23. Confidence in the “No Training” group also increased over time; however, Figure 24 highlights a small decrease in in high confidence detections during the final session.

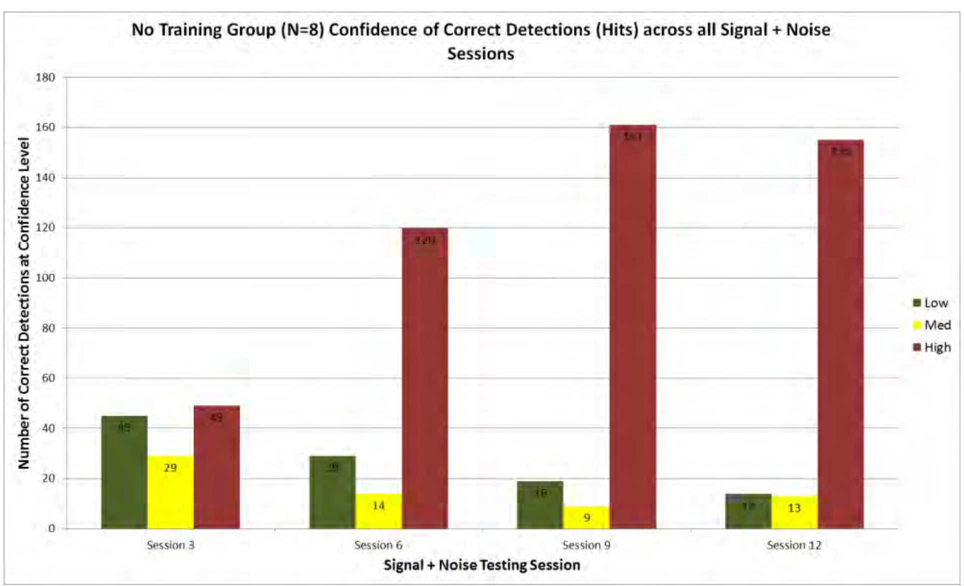


Figure 24. Confidence levels for “No Training” group, signal + noise

F. THREAT LEVEL EFFECTS

When analyzing the correct detection results by threat level, the research team concluded that a participant does not demonstrate a preference or an ability to detect one threat level above others. This result indicated that a user might not distinguish between a target's threat level when identifying changes. The variance in the subjective SME ratings for threat levels and small participant sample (N=15) prevent the research team from making any valid conclusions. Therefore, the team must retain the null hypothesis that there is no difference in the number of detections based on threat level. The results for this research question were inconclusive.

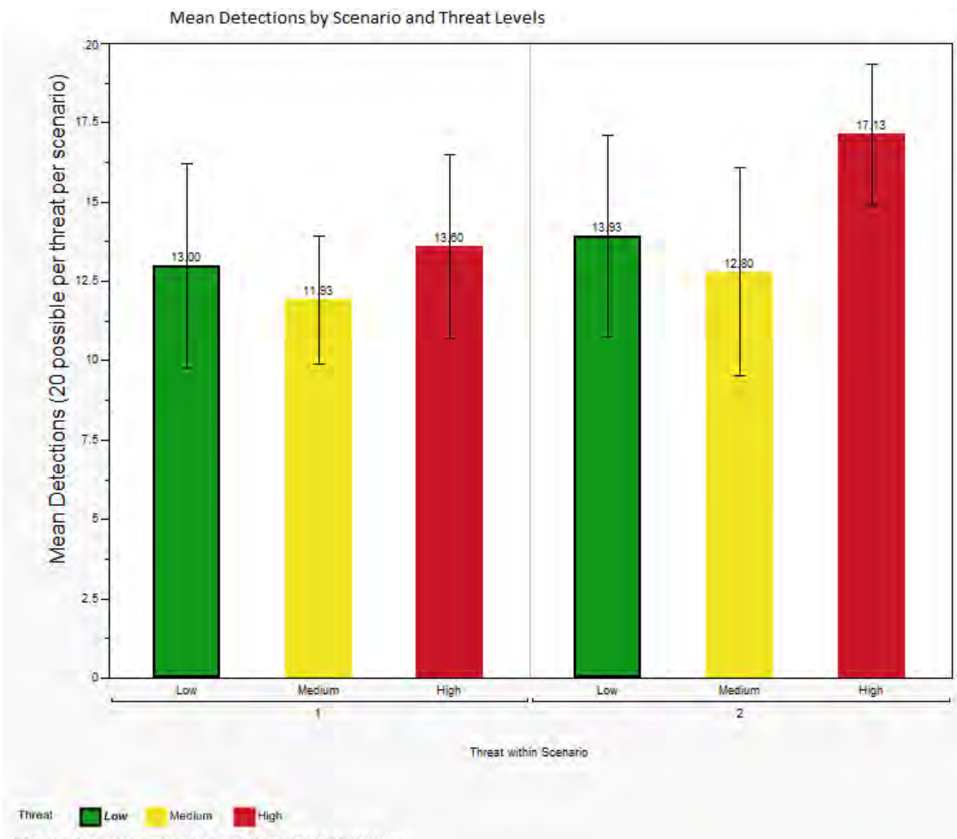


Figure 25. Distribution of mean detections by threat level

G. GROUPS

Two groups of participants completed the experiment. One hypothesis proposed by the research team was that participants receiving an automated virtual tutor would perform better at a change detection task than those who received no training. Participants of equivalent, rank, branch-of-service, combat experience, and video game ability were assigned to each group. The results were surprising in that both groups performed almost equally. This does not necessary say that training did not have an effect on those in the training group, but the research team cannot say that the automated tutor helped the participants in that group perform better as a group when compared to the group that did not receive any training.

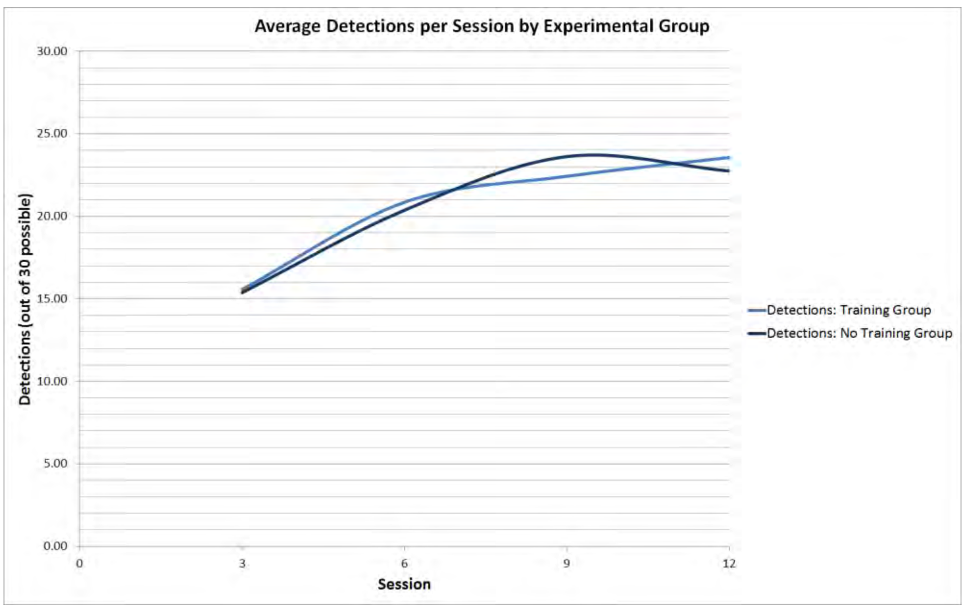


Figure 26. Mean detections per session by experimental group

Figure 22 shows how closely the two groups performed throughout all the signal-plus-noise sessions. The two (2) curves differ by approximately one (1) detection in Session 12 and two (2) detections in Session 9.

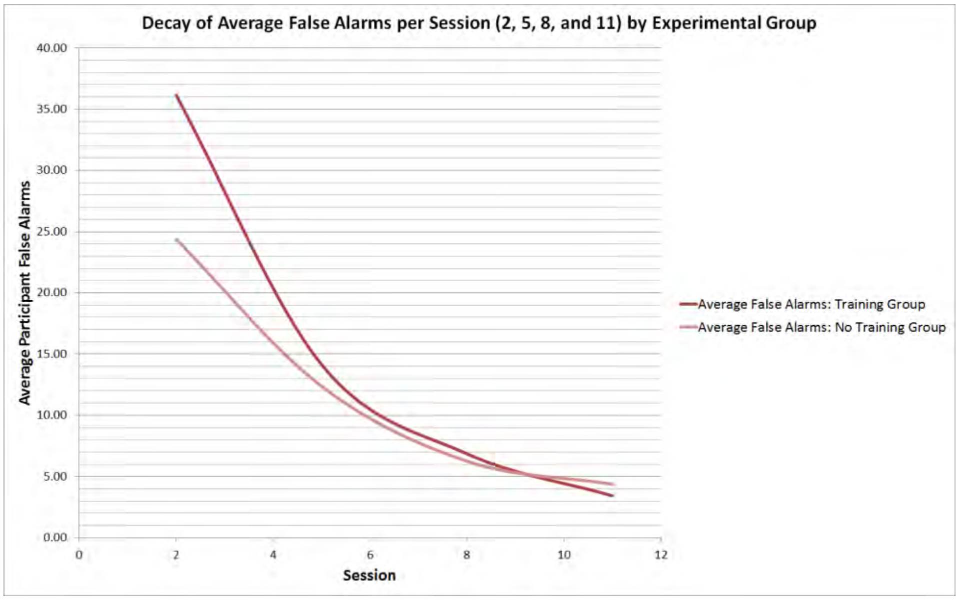


Figure 27. Mean false alarms per session by experimental group (N=15)

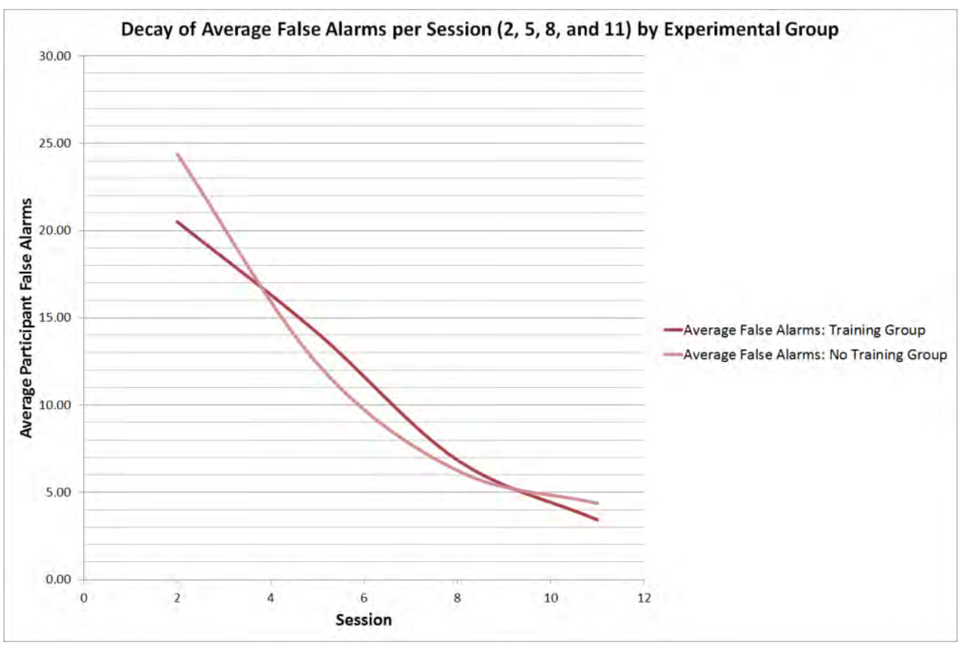


Figure 28. Mean false alarms per session by experimental group (N=14)

Similarly, false alarm rates were almost identical as well, as shown by Figure 27 and Figure 28. Interestingly, the average false alarm rate for the "training" group started higher than those without training. This was due to one participant logging 129-false alarms during Session 2. After removing his data from the false alarm data, the training group's average false alarms look similar to the no training group, as seen in Figure 28.

The similarity of experimental group performance due to small sample size prevents the research team from making any valid conclusions concerning the effect of tutorial training. Therefore, the team must retain the null hypothesis that says there is no difference in the performance of the "training" and "no training" groups.

H. OTHER EXPLORATORY QUESTIONS

The research team explored the possibility that selective demographic characteristics predict change detection performance. Specifically, the team looked at the sample population's age, rank, branch-of-service, combat experience, and video game experience. We expected that combat experience, branch-of-service, and video game experience might significantly contribute to improved performance at a change detection task in a virtual environment. For obvious reasons, the team thought that participants with ground combat experience would be better at detecting change. The team also thought participants who played video games would perform better in this particular virtual environment, since VBS2 is a Department of Defense (DoD) version of the commercial game Armed Assault™.

Using the data included in Appendix H, the team used JMP to determine if any factors contributed to better performance. JMP evaluated all data points for significance. The only factor that showed any significance was branch-of-service. Curiously, Navy and Air Force were the predictor variables that JMP identified with a low p-value of approximately 0.05. Based on the experience of the research team, this prediction was a surprise. As with threat level and group assignment, it appeared that the small sample size produced inconclusive results. Future studies with larger sample sizes are required to gain confidence in the results.

I. SCENARIOS

In the first pilot study, the research team suspected that at least one of the scenarios was more difficult than the other scenarios. Therefore, there was considerable effort to ensure that the two scenarios would be equally difficult for the thesis experiment. To validate this goal, the team plotted the results of both scenarios independent of each other for both iterations.

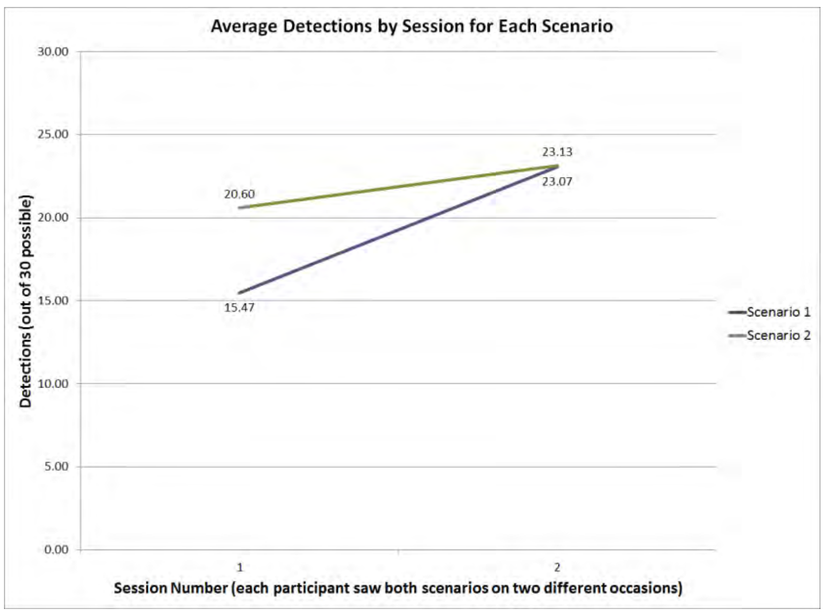


Figure 29. Average detections by session for each scenario

Clearly, there is improvement between the first session of Scenario 1 and the first session of Scenario 2. This report outlined the significance in the correct detections portion of this thesis. However, by the second time a participant saw each scenario, the results were almost identical. As seen in the correct detections analysis, it appears that the average number of correct detections approaches an asymptote for all participants. That asymptote appears to be the same regardless of scenario.

J. EXIT SURVEY

The results of the exit survey (Appendix H) revealed that 14 of the 15 participants felt they would perform better at change detection in the real world. Although subjective, this was an encouraging result for the validity of change detection training in a virtual environment. The same ratio of individuals also felt it was easier to detect more threatening changes. This is not supported by the data for threat level; however, participants reported high confidence in their ability to detect high threat changes. Of note, the dissenters in question 1 and question 3 were not the same participant.

#	Question	Yes	No
1	After completing these 12 sessions of Change Detection Training, do you feel that you would perform better at tasks related to identifying change in the real world?	14	1
2 Training	Do you feel that the tutorial lessons you received at the start of Weeks 1 and 7 helped you better identify change?	6	1
2 No Training	Do you feel that you would have performed better had you received instructional training as part of this experience?	7	1
3	Do you feel that it was easier to identify changes which indicated a high level threat vs. changes that suggested little or no threat?	14	1

Table 14. Exit survey results

Table 12 shows the slight differences in question 2 offered to each of the groups. In the "training" group, six of seven participants believed the training was beneficial. All but one participant in the "no training" group expressed that believed they would perform better with training. This was an interesting revelation, as the data showed no impact of the training on the change detection ability of the "training" group.

V. CONCLUSIONS AND RECOMMENDATIONS

A. OVERVIEW

A soldier's ability to detect changes in their environment is an invaluable skill on the battlefield. The first one-hundred days of combat present the most threat to warfighters due to unfamiliarity with the terrain, people, patterns, culture, attitudes, and beliefs in operational areas. Designing, developing, and validating a training method to mitigate the dangers presented in the first one-hundred days is a necessary research endeavor.

The purpose of this thesis was to develop and demonstrate a prototype change detection trainer. Ideally, the trainer would be easily distributable to DoD personnel, convenient, and fun. By using a video game for training, the research team hoped to create a method that was both engaging and productive. The team defined the problem as "can a desktop virtual trainer improve change detection skills?"

B. ANSWERS TO RESEARCH QUESTIONS

In order to answer the thesis's problem statement, we developed these research questions. The research team is now prepared to answer each of them:

1. Does change recognition performance improve over time in a virtual environment? How does it improve?

Yes, the data shows that performance does improve over time in a virtual environment. Participants improved at the number of changes detected, and they reduced the number of false alarms they committed over time.

a. Can a participant improve at recognizing that something has changed in general, measured by correct detections or detection percentages?

Yes, participants showed statistically significant improvement in the number of correct detections in signal plus noise scenarios.

b. Does a participant's confidence level improve at recognizing and identifying changes in a scene using a simple ordinal scale of high, medium, and low?

Yes, the data supports a significant improvement in user confidence over time. However, other factors, such as user apathy, could have confounded these results.

2. How do detection percentages differ when assessing a participant's performance on a variety of threat difficulty levels?

There is no significant statistical support to argue that the detection percentages are any different when grouped by threat level. These results could be skewed by SME subjectivity when rating the threats, or the way participants perceive the threats in the virtual environment.

3. How does automated virtual training affect change detection percentages?

This experiment showed no effect of automated virtual tutors on change detection training. Larger sample sizes would produce more confidence in this result. Additionally, the short six (6) minute tutorial was possibly not long enough to demonstrate significant results.

4. Does the percentage of recognized changes and false alarms grow proportionally? Alternatively, can the detection percentage improve while simultaneously decreasing the false alarm rate through repeated exposure to a simulated environment?

Yes, this research produced significant evidence that detection percentages increase while false alarm rates simultaneously decrease in a virtual environment.

C. OVERALL ASSESSMENT

There are numerous positive outcomes from this research effort. An analysis of the data reveals that all participants improved their change detection skills over the course of four weeks. The results showed that detections increased while false alarm rates decreased. This outcome indicates that participants became more sensitive to changes in their environment over time. The results also indicate a positive training effect within the virtual environment.

However, not all results turned out as expected. The effects of the additional tutorial training on performance were negligible. There was little data to support any effect of threat-level on a participant's recognition of change.

There are several possible hypotheses for why these unexpected results occurred that are covered in the next section; however, there is no definitive way to explain them with certainty. Future experimentation should investigate these issues and build upon the successful prototype design for training change detection.

D. LIMITATIONS

1. Sample Population

This study enlisted fifteen volunteers who participated consistently over four weeks. Mid-grade officers comprised a majority of the sample population. Additionally, all participants were students at the Naval Postgraduate School. While it is important for all soldiers and Marines to have change detection skills, a more appropriate sample would have represented young, enlisted combat-arms soldiers. These personnel would normally occupy a gunner position in a HMMWV or patrol on foot, constantly looking for threat indicators or changes to their environment.

2. Time

A second limitation on this study was the time available. This experiment lasted six-weeks, and each participant devoted four weeks of their time to training and testing. The research team wished that testing could have continued over six weeks and included additional sessions in order to gather more data. Limitations on both the research team and participant's time prohibited such a study. This time limitation prevented the team from recruiting more participants, enlisting a more representative sample, expanding the experiment over time, and evaluating the transfer of these skills to the real world. However, the results show that fewer sessions are necessary to demonstrate significant improvement.

With respect to the tutorial training sessions, the duration of six (6) minutes was too short to produce significant differences between groups. Allocating a greater proportion of training time to change detection tutorials might produce significant results.

3. Tasks

The research team limited participants to learning the virtual environment during baseline sessions and looking for changes during testing sessions. There were small sub-tasks such as moving the mouse to turn the head and pressing key combinations to turn the vehicle onto the next waypoint. The literature discusses the use of secondary tasks that can distract users and divide attention. While these types of tasks are realistic, the research team did not feel they were appropriate given the requirement to express confidence in the detected changes.

E. RECOMMENDATIONS

1. Scenario Recommendations

Future work using similar scenario designs should strive to improve the methods used in this thesis. VBS2 provides the capability for future researchers to immediately expand and improve the scenarios and scripts used in this study.

Scenario development should focus on comparing the effects of shorter session times. The duration of an individual session or the number of total sessions might produce revealing results, perhaps optimizing the time to train in a virtual environment for change detection tasks. Resulting data might alter when the user has reaches an asymptote in terms of performance.

The research team's scenario used existing VBS2 terrain and buildings. Using existing virtual terrain had the drawback of many repeated patterns through the scenario, and may have resulted in confounding effects over several sessions because repeated features were easy to identify as "noise" in the environment. A future scenario design would better replicate a real environment by creating few or no repeating structures. With the recent VBS2 1.50 update, existing buildings and other objects on the terrain constructed by Bohemia Interactive teams can be moved and replaced. This capability would enable creation of an environment with unique, non-repeating features.

The scenario used in this thesis had an automated system for identifying change. This method made it more difficult to assess the users' intent when they pressed a key to identify a change. Future work could better assess user intent by asking participants to verbalize change detections to an observer. Another possibility is to create a system where the simulation pauses while the user informs the system of their intent, leveraging speech recognition software.

Instead of repeating the same scenario each week, researchers could create a pre and post-training scenario using a completely new scenario and geographical area each. Assess whether the same reduction of false alarms and increase in correct detections exists despite a complete change of scenario.

2. Scoring Recommendations

The scoring methods used in this research accomplished the goals of logging detections and false alarms in the appropriate sessions. Developing a better scoring system that left no doubt about false alarms during the signal-plus-noise sessions would reveal the true number of false alarms in a continuous environment. This research team tested a method to accomplish that end during pilot studies, but it required a participant to verbalize their detections. While this method was foolproof for knowing the true number of false alarms, it would not allow a soldier to practice these scenarios independently. Therefore, verbalization of detections did not meet the intent of the prototype. The method utilized in this experiment was currently the best possible way to employ the categories of Signal Detection Theory in VBS2.

3. Recommendations for Future Work

a. Sample Population

Using this experimental design and scenario, future research should strive to obtain a sample population from Initial Entry Training (IET) soldiers. These are the soldiers that will occupy the front line, searching for change. Comparing a younger, enlisted population to the older, officer population may prove to be an interesting comparison of different populations.

Given more time and resources, future work with an IET population could test these scenarios on a much larger number of participants. A larger sample may reveal insights undiscovered by this research. It might create the condition where the automated virtual tutorial shows an ability to accelerate skill acquisition. Using an intelligent tutoring system (ITS) could also improve performance.

b. Transfer Study

One thing the research team cannot know is whether the prototype enables the effective transfer of change detection skills to real world conditions. This is an important next step for the trainer. Again, a population of IET soldiers who are about to undergo IED detection training as part of their Basic Training would be a perfect population to test. Allowing a sample population to use the prototype trainer developed by the research team and then negotiate a live detection course would be ideal. The results might better indicate whether the change detection trainer accomplished its mission.

c. Comparing Different Training Methods

Another approach for future work is to compare change detection training in virtual environments to training that utilizes still photographs or full-motion video. Designing an experiment where participants were able to do all three methods, VE, photos, and video, might reveal the benefits of each. Future training developers could create training packages for change detection that incorporated the best parts of each genre. A full curriculum focused on change detection training would likely be more beneficial than any one of these elements used independently.

d. Other Distributable Methods

Developing web based implementations of change detection training, possibly using Flash or HTML5 to allow distributed learning in a virtual environment has unlimited potential. Creating a operationally focused change detection “app” for mobile devices, such as a tablet or phone, would be extremely useful. This type of training would be more useful and accessible to every soldier.

e. Expanded Training Cognitive Skills Training Approached

In the introduction to methodology, the research team identified eight (8) primary tasks. These tasks all required improved cognitive abilities. Expanding change detection skill training to include memory training, such as remembering HVT faces, recalling BOLO vehicles, and remembering CCIR enhances readiness for the COE.

f. Other Devices

The objective of the research team was to make a change detection trainer that could have an immediate impact on training within the Army or Marine Corps. To meet that end, a heavy reliance on uncommon input devices or output devices defeated the purpose. The tool described in this thesis represented a training device that a soldier could use with any computer and a mouse. However, there is much potential for future work using head mounted displays, head trackers, and eye tracking. In addition to these technologies, using voice recognition input devices for detecting targets might be one way to eliminate erroneous false alarms. The potential for future exploration using a multitude of input and output devices leaves the area of change detection in a virtual environment an interesting and worthy pursuit.

APPENDIX A. PRE-EXPERIMENT INSTRUCTIONS AND MATERIALS

A. MAP

Every participant received a copy of this map prior to the experiment. This map was also available to every participant during experimentation.

Figure 30. Overhead map provided to each participant

B. NO TRAINING GROUP

Welcome to Change direction training.

This is a four-week long experiment. Each week will follow the same procedure.

Each week you will participate in one 15-minute session on day one, a 15-minute session on day two, and a final 15-minute session on day three.

In order to save time, the scenario will be ready to start when you arrive to the testing location. As soon as you take your seat, you will be allowed to start the session.

Your role is the gunner for a HMMWV on patrol in a Middle-Eastern city. Attached to this document is a map that you can use to orient yourself to the patrol route.

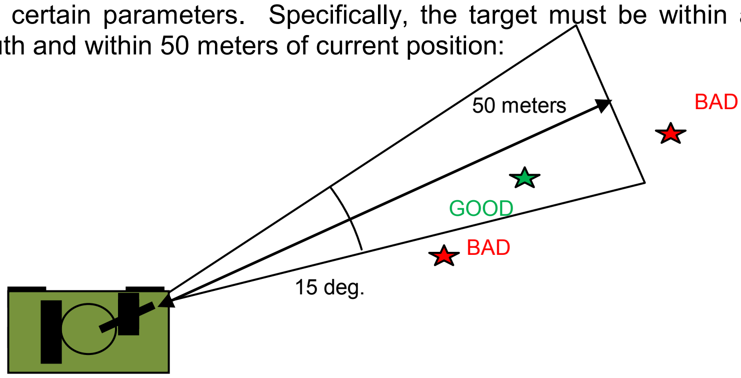
For the most part, navigation will be handled by an automated driver. However, when the vehicle comes to a stop, it is up to you to order the vehicle to proceed to the next waypoint by pushing the **standard keyboard number keys 1 and then 9**.

Moving the mouse will allow you to slew your gun turret and thereby change your view.

Your task for the day one session is to become as familiar as possible with the presented virtual city area . During the first session, you will only be viewing the environment by moving the mouse. Make "mental notes" and try to learn the environment. You will not be required to identify any changes in the first session.

Your task for the second and third sessions are different from the first session. You are to identify changes in the second and third session environments by pressing labeled keys corresponding to your confidence level that something has changed from what you saw in the first session environment. (H-most confident to L-least confident)

In order for the system to correctly register your identification of a change, the target must be within certain parameters. Specifically, the target must be within a 7.5 degree arc of the gun azimuth and within 50 meters of current position:



Other than the changes, you are always following the same patrol route through the same city streets. Learn your environment in the first session of each week to become better at recognizing the potential changes in the second and third session.

You will not be presented with your scores until after the entire experiment is complete. However, you will hear an audible tone when you have correctly identified a change during the second and third sessions.

C. TRAINING GROUP

Welcome to Change direction training.

This is a four-week long experiment. Each week will follow the same procedure.

Each week you will participate in one 20-minute session on day one, a 15-minute session on day two, and a final 15-minute session on day three.

In order to save time, the scenario will be ready to start when you arrive to the testing location. As soon as you take your seat, you will be allowed to start the session.

Your role is the gunner for a HMMWV on patrol in a Middle-Eastern city. Attached to this document is a map that you can use to orient yourself to the patrol route.

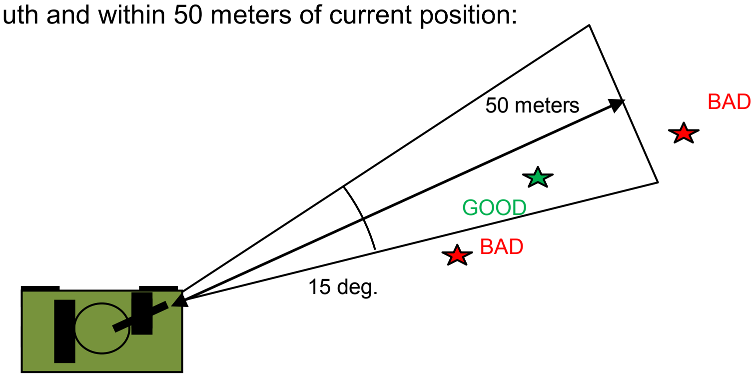
For the most part, navigation will be handled by an automated driver. However, when the vehicle comes to a stop, it is up to you to order the vehicle to proceed to the next waypoint by pushing the **standard keyboard number keys 1 and then 9**.

Moving the mouse will allow you to slew your gun turret and thereby change your view.
Your task for the day one session is to become as familiar as possible with the presented virtual city area . During the first session, you will only be viewing the environment by moving the mouse. Make "mental notes" and try to learn the environment. You will not be required to identify any changes in the first session.

Prior to this first session, you will be presented with a short tutorial session.

Your task for the second and third sessions are different from the first session. You are to identify changes in the second and third session environments by pressing labeled keys corresponding to your confidence level that something has changed from what you saw in the first session environment. (H-most confident to L-least confident)

In order for the system to correctly register your identification of a change, the target must be within certain parameters. Specifically, the target must be within a 7.5 degree arc of the gun azimuth and within 50 meters of current position:



Other than the changes, you are always following the same patrol route through the same city streets. Learn your environment in the first session of each week to become better at recognizing the potential changes in the second and third session.

You will not be presented with your scores until after the entire experiment is complete. However, you will hear an audible tone when you have correctly identified a change during the second and third sessions.

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APPENDIX B. COMPUTER SET-UP

- Install VBS2 1.31 or better, VTK version or “Lite” version.
- Label the “C,” “V,” and “B” keys of the keyboard “H,” “M” and “L” for ease of recognition by the participant.
- From the archive on the DVD, extract the ***Change Detection Training*** folder to the main VBS2 install folder’s mission folder; this should be located at ***C:\Bohemia Interactive\VBS2\missions*** if VBS2 is installed on the C drive. See Figure 31.

Figure 31. File view for training scenarios

- The mission folders in ***.../missions*** should include:

  Session_1.map_samawah50km_ieed.pbo

  Session_2.map_samawah50km_ieed.pbo

  Session_3.map_samawah50km_ieed.pbo

  Session_4.map_samawah50km_ieed.pbo

  Session_5.map_samawah50km_ieed.pbo

  Session_6.map_samawah50km_ieed.pbo

  Session_7.map_samawah50km_ieed.pbo

Session_8.map_samawah50km_ieed.pbo

Session_9.map_samawah50km_ieed.pbo

Session_10.map_samawah50km_ieed.pbo

Session_11.map_samawah50km_ieed.pbo

Session_12_Training.map_samawah50km_ieed.pbo

Session_12_Non_Training.map_samawah50km_ieed.pbo

TrainingSession_1A.map_samawah50km_ieed.pbo

TrainingSession_1B.map_samawah50km_ieed.pbo

TrainingSession_2A.map_samawah50km_ieed.pbo

Training2Session_2B.map_samawah50km_ieed.pbo

- Open VBS2.
- Select “Training Scenarios” from the main menu.
- Select “Change Detection Training” and click “Open”
- Ensure the participant is wearing headphones or using speakers at an appropriate volume level and sitting comfortably.
- For the first session, select the appropriate scenario. Click “Start.”
- From the same “File” menu, select “Preview.”
- The participant should follow all instructions given in the scenario which features voiceover instructions.
- At the conclusion of the scenario, press the “ESC” key. Click “Abort.” Now, additional scenarios can be run in the same manner. However, it is critical that any data files be extracted as follows in the next step BEFORE running another scenario. If data is not extracted before running another scenario, it will be overwritten.
- All scenarios, except the training scenarios, will write to data files in the actual VBS2 root directory. If VBS2 was installed to the C drive using the default settings, this path will be C:\Bohemia Interactive\VBS2. Table 15 shows which data files should be obtained from this directory immediately after a participant has finished.

Scenario	headDirection.txt	startTimes.txt	clicked.txt	targetFinalScore.txt	targetsFound.txt	Survey.txt
1,4,7,10	√					
2,5,8,11	√	√	√	√		
3,6,9	√	√	√	√	√	
12	√	√	√	√	√	√
Training						

Table 15. Data file matrix for training scenarios

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APPENDIX C. APPROVED IRB PROTOCOL

Naval Postgraduate School
Human Research Protection Program

From: President, Naval Postgraduate School
Via: Chairman, Institutional Review Board
To: Dr. Michael McCauley, MOVES Institute
Dr. Quinn Kennedy, Operation Research Department
Dr. Anthony Ciavarelli
MAJ Jason Caldwell, USA
MAJ Michael Stinchfield, USA

Subj: CHANGE DETECTION: STUDYING THE EFFECTS OF TRAINING FREQUENCY AND THREAT SALIENCY ON PERFORMANCE IN A VIRTUAL ENVIRONMENT

Encl: (1) Approved IRB Protocol

1. The NPS IRB is pleased to inform you that the NPS Vice President and Dean of Research has approved your project (NPS IRB# NPS.2011.0064-IR-CONV-A). The approved IRB protocol is found in enclosure (1). Completion of the CITI Research Ethics Training has been confirmed.

2. This approval expires on 30 September 11. If additional time is required to complete the research, a continuing review report must be approved by the IRB and NPS President prior to the expiration of approval. At expiration all research (subject recruitment, data collection, analysis of data containing PII) must cease.

3. Dr. Anthony Ciavarelli may not engage in research activities until NPS and DON HRPP have approved an Individual Investigator Agreement (IIA) allowing Dr. Ciavarelli coverage under the NPS assurance to conduct research with human subjects. The IRB Administrator will provide written approval to the research team once received.

4. You are required to report to the IRB any unanticipated problems or serious adverse events to the NPS IRB within 24 hours of the occurrence.

5. Any proposed changes in IRB approved research must be reviewed and approved by the NPS IRB and NPS President prior to implementation except where necessary to eliminate apparent immediate hazards to research participants and subjects.

6. As the Principal Investigator it is your responsibility to ensure that the research and the actions of all project personnel involved in conducting this study will conform with the IRB approved protocol and IRB requirements/policies.

7. After the experiment is completed the Principal Investigator will submit to the Human Subjects Protection Office, all signed informed consent documents, unanticipated problem reports, adverse event reports and a End of Experiment Report. The Human Research Protection Program Office will secure these documents for 10 years and then forward to the nearest FRC.

John K. Schmidt

CAPT John K. Schmidt, MSC USN
Chair
Institutional Review Board

D T Oliver

Daniel T. Oliver
President
Naval Postgraduate School

APPENDIX D. INFORMED CONSENT

Change Detection: Studying the Effects of Training Frequency and Threat Saliency on Performance in a Virtual Environment

Informed Consent Form

Introduction. You are invited to participate in a research study entitled: "Change Detection: Studying the Effects of Training Frequency and Threat Saliency on Performance in a Virtual Environment

Procedures. This study requires a participant to view a virtual environment in a "normal" state, and then subsequently detect changes that occur in the same environment over the course of four (4) weeks. Participants will fill out a short demographic questionnaire to better understand the user's military experience and level of computer gaming expertise. The survey should take no longer than one (1) minute to complete. Assistance will be given, if required. During the first two sessions, there will be an overview brief that explains the target detection task in the virtual environment and the participant's role in the scenario. There will be time for questions after the brief. The briefing will take no longer than two (2) minutes. Users will then complete twelve (12), 15-minute scenarios detecting as many changes as possible in a simulated environment. Each participant will conduct only one (1) of the scenarios in a single day. At the conclusion of the experiment (all 12-scenarios), users will be released from the study.

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. If you choose to participate you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw.

Potential Risks and Discomforts. The potential risks of participating in this study are not greater than minimal risk. There is the possibility of a participant experiencing simulator sickness or head ache. This possibility is no greater than those encountered when playing civilian video games. If you feel nauseous or dizzy, inform the observers and they will escort you outside. If you cannot complete the training, it will be rescheduled. If a participant continues to experience these effects, they can withdraw from the study at any time.
There is the additional risk of experiencing Post-Traumatic Stress Disorder (PTSD) symptoms due to the detailed nature of the virtual environment. <u>***If you have experienced the symptoms of post traumatic stress disorder or been treated previously for post traumatic stress disorder, please notify the data collector and remove yourself from participation in this study***</u>. <u>***Possible***</u>

symptoms include: 1) flashbacks, 2) hallucinations, 3) psychological or physiological distress, 4) avoidance, 5) lack of ability to recall details of the event, 6) difficulty falling asleep, 7) irritability or outbursts of anger, 8) difficulty concentrating, and 9) being easily startled. If you feel PTSD-like stress, notify the observers and you will be removed from the testing area, provided points of contact numbers and withdrawn from the study. Medical support for those experiencing difficulties is available at 831–242–4328 at the Presidio of Monterey Wellness Center, BLD 454.

Anticipated Benefits. The ability to detect changes in an environment is an important skill throughout the Department of Defense (DoD). By showing that virtual environment training improves change recognition skills, we demonstrate the viability of VBS2 as a desktop solution for soldiers as a part-task trainer. Since all U.S. Army soldiers have access to VBS2 for their personal computers, our research could make change detection training more accessible to the individual user. This training could reduce the risk of casualties from a variety of asymmetric threats in the first one-hundred days in combat and beyond.

Compensation for Participation. Participants in this experiment will be invited to a "Thank You Event" that will include food and drink, such as a pizza party or dinner party, to occur at the end of the Spring 2011 Quarter. Additionally, a copy of the research results will be available at the conclusion of the experiment by contacting MAJ Jason Caldwell or MAJ Mike Stinchfield.

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential, but total confidentiality cannot be guaranteed.

All completed surveys will be sent via encrypted and digitally signed emails. If it is necessary to print any surveys, all personally identifiable information (PII) will be scrubbed so the participant cannot be identified. All printed surveys will be stored in a locked drawer or facility when not in use. In the final publication, no names will be used for privacy and because it adds no value to the research.

Points of Contact. If you have any questions or comments about the research, or you experience an injury or have questions about any discomforts that you experience while taking part in this study, please contact the Principal Investigator, Dr. Michael McCauley, memccaul@nps.edu. Questions about your rights as a research subject or any other concerns may be addressed to the Naval Postgraduate School IRB Chair, CAPT John Schmidt, USN, 831–656–3864, jkschmid@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

_______________________________ _______________

Participant's Signature Date

_______________________________ _______________

Researcher's Signature Date

MAJ Jason C. Caldwell

_______________________________ _______________

Researcher's Signature Date

MAJ Michael K. Stinchfield

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APPENDIX E. DEMOGRAPHIC SURVEY

1. Please enter your age: _____**years old**

2. Are you a male or female? (Circle one) **MALE** **FEMALE**

3. Please indicate your military service branch or select civilian (Circle One).

Army	**Marine Corps**	**Navy**	**Air Force**
Civilian	**Retired Military**	**International Military Member**	

4. Please indicate your military grade (eg. O-3, O-4, E-6, etc) ___-____

5. Do you play video games on computers (Do **NOT** count consoles – Xbox, PS3, Wii)? Circle one:
YES **NO**

6. Circle the most descriptive unit of measurement that describes the amount of time you have played computer-based First Person Perspective (First Person Shooters) video games:
N/A **HOURS** **DAYS** **WEEKS** **MONTHS** **YEARS**

7. Do you consider yourself a gamer? (Circle One) **YES** **NO**

8. Have you conducted urban ground combat operations involving a search or target/change detection task? (Example: Neighborhood patrol in Iraq/Afghanistan, Route clearance operations, etc)
YES **NO**

9. Do you have 20/20 vision, or correctable to 20/20 vision? **YES** **NO**

10. Are you color blind? **YES** **NO**

11. Have you ever experienced Post-Traumatic Stress (PTS) symptoms that might be aggravated by seeing computer images of terrain that looks like Iraq or Afghanistan (examples: upsetting memories, flashbacks, nightmares, feelings of intense distress, or physical reactions – pounding heart, rapid breathing, nausea, muscle tension, sweating)? If so, inform the research team that you will be unable to participate in this study.

12. Have you ever experienced simulator sickness? **YES** **NO**

13. Rate your agreement with the following statement: "Computer based simulation can be an effective training tool for unit tactical training."

Strongly Disagree

Moderately Disagree

Mildly Disagree

No Opinion

Mildly Agree

Moderately Agree

Strongly Agree

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APPENDIX F. VIRTUAL BATTLESPACE2 ™ SCRIPTS

A. INTRODUCTION

External script file code bound to C,V, and B keys in “init.sqf” file. Code executes when bound button is pressed.

B. KEY BINDING CODE

1. High Confidence

(“B” keyboard key bound to lookat3.sqf)

```
totalClicks = totalClicks + 1;
clickH = clickH + 1;
_3click = “highConf”;
_blank = ““;
_headDir = getDir player;
_vehDir = getDir veh_1;
_relDir = _headDir - _vehDir;
_time = time;
_filename = “targetsFound.txt”;
_filename3 = “clicked.txt”;
_append = format[“AppendLine(%1)@%2,%3,%4,”_filename3,_3click,_relDir,_time];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
{
```

```
if ((player isLookingAt [_x,15]) && ((player distance _x) < 60)) then{
_filename = “targetsFound.txt”;
_confidence = “conf1correct”;
scoreH = scoreH + 1;
totalCorrect = totalCorrect + 1;
_append = format[“AppendLine(%1)@%2,%3,%4,%5,”_filename,_x,_relDir,_time,_3click];
    _writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
playSound “dinger”;
};
}forEach myArray;
```

2. Mid Confidence

(“V” keyboard key bound to lookat2.sqf)

```
totalClicks = totalClicks + 1;
clickM = clickM + 1;
_2click = “midConf”;
_blank = ““;
_headDir = getDir player;
_vehDir = getDir veh_1;
_relDir = _headDir - _vehDir;
_time = time;
_filename = “targetsFound.txt”;
_filename3 = “clicked.txt”;
```

```
_append = format["AppendLine(%1)@%2,%3,%4,"_filename3,_2click,_relDir,_time];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
{
if ((player isLookingAt [_x,15]) && ((player distance _x) < 60)) then{
_filename = "targetsFound.txt";
_confidence = "conf1correct";
scoreM = scoreM + 1;
totalCorrect = totalCorrect + 1;
playSound "dinger";
_append = format["AppendLine(%1)@%2,%3,%4,%5,"_filename,_x,_relDir,_time,_2click];
    _writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
playSound "dinger";
};
}forEach myArray;
```

3. Low Confidence

("C" keyboard key bound to lookat1.sqf)

```
totalClicks = totalClicks + 1;
clickL = clickL + 1;
_1click = "lowConf";
_blank = "";
_headDir = getDir player;
```

```
_vehDir = getDir veh_1;
_relDir = _headDir - _vehDir;
_time = time;
_filename = “targetsFound.txt”;
_filename3 = “clicked.txt”;
_append =
format[“AppendLine(%1)@%2,%3,%4,”_filename3,_1click,_relDir,_time];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
{
if ((player isLookingAt [_x,15]) && ((player distance _x) < 60)) then{
_filename = “targetsFound.txt”;
_confidence = “conf1correct”;
scoreL = scoreL + 1;
totalCorrect = totalCorrect + 1;
_append =
format[“AppendLine(%1)@%2,%3,%4,%5,”_filename,_x,_relDir,_time,_1click];
    _writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
playSound “dinger”;
};
}forEach myArray;
```

C. SCENARIO INITIALIZATION FILE CODE

This code edeuctes the “init.sqf” file when the scenario begins

1. Session 1

_blank = "";

_filename2 = "headDirection.txt";

_append = format["Write(%1)@%2,"_filename2,_blank];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

hint "Aim at the Yellow Cross. This is the maximum distance at which the system will allow you to identify changes. The Green Arrows represent the maximum allowable azimuth error.";

playSound "tolerance";

sleep 23;

gal setPos (getPos remove);

gar setPos (getPos remove);

yc setPos (getPos remove);

hint "In this scenario today, you will not be identifying changes. You are to conduct observation as the gunner during the patrol. Move your mouse to rotate your view. Learn this environment. In the next two sessions, you will be required to identify things that have changed from the environment you see today.";

playSound "introSceneOne";

sleep 25;

hint "Every session's patrol route will be the same. It will last approximately 12 minutes. We will follow Route Blue, straight ahead of you. Then, we will make a right turn on Route Red. Then, when we reach Route Green at Victory Bridge, we will take another right and follow Route Green along the river. At the end of Route Green, we will make a right turn onto Route Purple for the final portion of our patrol. Again, every session's patrol will follow this same route.";

playSound "route";

sleep 35;

hint "Again, it is important to understand that today's session exposes you to the base or baseline environment. You will be required in the other two sessions of this week to identify changes from this environment you see today. As we proceed with the training, you will see this baseline environment as the first session of every week.";

playSound "baseline";

sleep 25;

hint "Now, press 1 then 9 to start your patrol up Route Blue";

playSound "oneNine";

```
while {alive player} do
{
    _headDir = getDir player;
    _vehDir = getDir veh_1;
    _relDir = _headDir - _vehDir;
    _time = time;
    _append = format["AppendLine(%1)@%2,%3,"_filename2,_relDir,_time];
    _writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
    sleep 0.2;
};
```

2. Session 2

```
0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;
0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;
0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;
myArray = [fake_truck];
_blank = ““;
totalClicks = 0;
totalCorrect = 0;
scoreL = 0;
scoreM = 0;
scoreH = 0;
clickL = 0;
clickM = 0;
clickH = 0;
_filename = “targetsFound.txt”;
_filename2 = “headDirection.txt”;
_filename3 = “clicked.txt”;
_filename4 = “startTimes.txt”;
_append = format[“Write(%1)@%2,”_filename,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename2,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename3,_blank];
```

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

_append = format[“Write(%1)@%2,”_filename4,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

hint “Welcome to day two of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today’s session, you will attempt to identify any changes from that baseline environment. Please be patient and listen closely as I share some important instructions.”;

playSound “welcomeDayTwo”;

sleep 22;

hint “To identify changes, you will aim the gun at the location and then press the key labeled H, M, or L according to your confidence level that something has changed from the baseline session -- High Confidence, Mid-Level Confidence, Low Confidence, respectively.”;

playSound “conflevels”;

sleep 20;

hint “Remember from the instruction sheet you received, that the target you want to identify must be within 50 meters of your location and within a 15 degree cone for the system to register a hit, even if it is an actual change. Displayed right now for your understanding are green arrows ahead of you on the road displaying the limits of this area. If you try to identify a target outside these parameters, it will not register as a hit and will in fact register as a miss. Misses will count against your total score. It is best to wait until you have the location you want to target reasonably close before pressing the desired key.”;

playSound “targeting”;

sleep 40;

hint “I will now remove the arrows”;

playSound “removal”;

sleep 4;

ga1 setPos (getPos remove);

ga2 setPos (getPos remove);

ga3 setPos (getPos remove);

ga4 setPos (getPos remove);

ga5 setPos (getPos remove);

ga6 setPos (getPos remove);

ga7 setPos (getPos remove);

ga8 setPos (getPos remove);

ga9 setPos (getPos remove);

ga10 setPos (getPos remove);

ga11 setPos (getPos remove);

ga12 setPos (getPos remove);

yc setPos (getPos remove);

sleep 1;

hint “If you have identified an actual change within the specified parameters, you will hear a short ding confirming the hit. If you press a button while targeting anything else, or are outside the parameters, you will hear nothing. Do not get frustrated, you have only seen the baseline once so far in this first week of training. Just continue to learn the baseline environment better each time you see it as the first session of a week.”;

playSound “dingExplanation”;

sleep 28;

hint “There is a white pick-up truck to the right of the road ahead of you. Go ahead and aim at the truck with your gun and press the key labeled H to attempt to identify it as a change with high confidence. You will not hear any confirmation sounds, because the truck is too far away. In a few minutes, after we have started moving and are a little closer, I will ask you again to attempt to identify the truck.”;

playSound “truckTest”;

sleep 25;

hint “Today’s patrol will follow the same route as your last session and as seen on the map at your training station. Identify any changes from the baseline environment during this 12-minute patrol.”;

playSound “patrolTime”;

sleep 13;

hint “Now, press 1 then 9 to start your patrol up Route Blue”;

playSound “oneNine”;

while {alive player} do

{

_headDir = getDir player;

_vehDir = getDir veh_1;

_relDir = _headDir - _vehDir;

_time = time;

_append = format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

sleep 0.2;

};

3. Session 3

0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;

0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;

0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;

myArray = [tire_1,burnt_truck_1,propane_tank_sales_1,broken_wall_1,dirt_pile_1,vid_camera_1,observer_1,running_man_1,ied_box_1,ied_supply_man_1,odd_drums_1,vbied_van_1,ied_patch_1,burkha_girl_1,ruined_house_1,broken_wall_2,bad_trash_pile_1,broken_wall_ied_1,broken_guardrail_1,bad_curb_1,reporter_1,bad_bag_pile_1,
bad_barrels_1,bad_rubble_1,broken_fence_no_ip_1,buried_tank_1,new_containers_1,poster_wall_1,concrete_ied_1,bad_mixer_1];

_blank = ““;

totalClicks = 0;

totalCorrect = 0;

scoreL = 0;

scoreM = 0;

scoreH = 0;

clickL = 0;

clickM = 0;

clickH = 0;

_filename = “targetsFound.txt”;

_filename2 = “headDirection.txt”;

_filename3 = “clicked.txt”;

_filename4 = “startTimes.txt”;

_append = format[“Write(%1)@%2,”_filename,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

_append = format[“Write(%1)@%2,”_filename2,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

_append = format[“Write(%1)@%2,”_filename3,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

_append = format[“Write(%1)@%2,”_filename4,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

hint “Welcome to day three of Change Detection Training. In session one, you observed the baseline environment. In your last session, you attempted to identify changes in the environment. It was likely a little frustrating since the environment is still so new to you. However, with each session you should become more accustomed to the sights and activity of the patrol area. Today, you will have another opportunity to identify changes from the baseline environment that you observed during the first session of this week.”;

playSound “welcomeDayThree”;

sleep 30;

hint “As a reminder, to identify changes, you will aim the gun at the location and then press the key labeled H, M, or L according to your confidence level that something has changed from the baseline session -- High Confidence, Mid-Level Confidence, Low Confidence, respectively.”;

playSound “conflevelsThree”;

sleep 19;

hint “Remember from the instruction sheet you received, that the target you want to identify must be within 50 meters of your location and within a 15 degree cone for the system to register a hit, even if it is an actual change. If you have identified an actual change within the specified parameters, you will hear a short sound confirming the hit. If you press a button while targeting anything else that is not a change, or are outside the parameters, you will hear nothing.”;

playSound “targetingThree”;

sleep 27;

hint “Today’s patrol will follow the same route as your last session and as seen on the map at your training station. Identify any changes from the baseline environment during this 12-minute patrol. You may now begin your patrol up Route Blue by pressing 1 then 9. Good Luck”;

playSound “patrolGo”;

while {alive player} do

{

_headDir = getDir player;

_vehDir = getDir veh_1;

_relDir = _headDir - _vehDir;

_time = time;

_append = format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

sleep 0.2;

};

4. Session 4

```
_blank = "";

_filename2 = "headDirection.txt";

_append = format["Write(%1)@%2,"_filename2,_blank];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

hint "Welcome to the second week of Change Detection Training.  This is your first session of three sessions for this week.  Like last week, in this first session you will be exposed to the baseline environment.  It is exactly the same baseline that you saw in last week's first session.  Therefore, today your task is simply to observe the environment so that you are prepared to identify changes in the next two sessions.  You will not be clicking or pressing H, M, or L for anything today.  When you are ready to begin, press 1 then 9.";

playSound "weekTwoSessionOne";

while {alive player} do

{

    _headDir = getDir player;

    _vehDir = getDir veh_1;

    _relDir = _headDir - _vehDir;

    _time = time;

    _append = format["AppendLine(%1)@%2,%3,"_filename2,_relDir,_time];

    _writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

    sleep 0.2;

};
```

5. Session 5

```
0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;
0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;
0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;
myArray = [];
_blank = ““;
totalClicks = 0;
totalCorrect = 0;
scoreL = 0;
scoreM = 0;
scoreH = 0;
clickL = 0;
clickM = 0;
clickH = 0;
_filename = “targetsFound.txt”;
_filename2 = “headDirection.txt”;
_filename3 = “clicked.txt”;
_filename4 = “startTimes.txt”;
_append = format[“Write(%1)@%2,”_filename,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename2,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename3,_blank];
```

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

_append = format[“Write(%1)@%2,”_filename4,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

hint “Welcome to day two of week 2 of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today’s session, you will attempt to identify any changes from that baseline environment. Use the H, M, and L keys to indicate your confidence level when identifying a suspected change.”;

playSound “welcomeDayTwo”;

sleep 20;

hint “Now, press 1 then 9 to start your patrol up Route Blue”;

playSound “oneNine”;

while {alive player} do

{

_headDir = getDir player;

_vehDir = getDir veh_1;

_relDir = _headDir - _vehDir;

_time = time;

_append = format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

sleep 0.2;

};

6. Session 6

0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;

0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;

0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;

myArray = [fridge_no_play,truck_wreck,suicide_bomber,dead_body,bomb_maker,new_rock, new_van,boarded_up_shop,weird_dudes,bomb_car,press_man,back_to_back_vans,UN_sacks,ice_cream_dude,bad_pile,new_boxes_no_phone_booth,new_tractor,new_car_open_street,nobody_ia_cp,broken_wall,jingle_truck,turned_truck,new_rubble_no_kids,
wall_truck,ip_suicide_bomber,propane_tanks,bad_cart,van_bomb,new_cars,new_barrels];

_blank = ““;

totalClicks = 0;

totalCorrect = 0;

scoreL = 0;

scoreM = 0;

scoreH = 0;

clickL = 0;

clickM = 0;

clickH = 0;

_filename = “targetsFound.txt”;

_filename2 = “headDirection.txt”;

_filename3 = “clicked.txt”;

_filename4 = “startTimes.txt”;

```
_append = format["Write(%1)@%2,"_filename,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename2,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename3,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename4,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
hint "This is Session 3 and the last session for this week.  Like your last session, in today's session you will be asked to identify changes according to your confidence level.  Identify any changes you see from the baseline environment you observed in the first session this week.  Press 1 then 9 when you are ready to begin";
playSound "welcomeDayThree";
sleep 22;
while {alive player} do
{
	_headDir = getDir player;
	_vehDir = getDir veh_1;
	_relDir = _headDir - _vehDir;
	_time = time;
	_append = format["AppendLine(%1)@%2,%3,"_filename2,_relDir,_time];
	_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
```

sleep 0.2;

};

7. Session 7

_blank = "";

_filename2 = "headDirection.txt";

_append = format["Write(%1)@%2,"_filename2,_blank];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

hint "Welcome to the third week of Change Detection Training. This is your first session of three sessions for this week. Like last week, in this first session you will be exposed to the baseline environment. It is exactly the same baseline that you saw in the last two weeks' first session. Therefore, today your task is simply to observe the environment so that you are prepared to identify changes in the next two sessions. You will not be clicking or pressing H, M, or L for anything today. When you are ready to begin, press 1 then 9.";

playSound "weekTwoSessionOne";

while {alive player} do

{

_headDir = getDir player;

_vehDir = getDir veh_1;

_relDir = _headDir - _vehDir;

_time = time;

_append = format["AppendLine(%1)@%2,%3,"_filename2,_relDir,_time];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

```
        sleep 0.2;
};
```

8. Session 8

```
0x2E bindKey "nul = [] execVM 'lookat1.sqf'";
0x2F bindKey "nul = [] execVM 'lookat2.sqf'";
0x30 bindKey "nul = [] execVM 'lookat3.sqf'";
myArray = [];
_blank = "";
totalClicks = 0;
totalCorrect = 0;
scoreL = 0;
scoreM = 0;
scoreH = 0;
clickL = 0;
clickM = 0;
clickH = 0;
_filename = "targetsFound.txt";
_filename2 = "headDirection.txt";
_filename3 = "clicked.txt";
_filename4 = "startTimes.txt";
_append = format["Write(%1)@%2,"_filename,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename2,_blank];
```

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

_append = format["Write(%1)@%2,"_filename3,_blank];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

_append = format["Write(%1)@%2,"_filename4,_blank];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

hint "Welcome to day two of week 3 of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today's session, you will attempt to identify any changes from that baseline environment. Use the H, M, and L keys to indicate your confidence level when identifying a suspected change. Remember that misses count against your score so you should have some level of confidence that something has changed before pressing a key.";

playSound "welcomeDayTwo";

sleep 28;

hint "Now, press 1 then 9 to start your patrol up Route Blue";

playSound "oneNine";

while {alive player} do

{

_headDir = getDir player;

_vehDir = getDir veh_1;

_relDir = _headDir - _vehDir;

_time = time;

_append = format["AppendLine(%1)@%2,%3,"_filename2,_relDir,_time];

_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];

sleep 0.2;

};

9. Session 9

0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;

0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;

0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;

myArray = [tire_1,burnt_truck_1,propane_tank_sales_1,broken_wall_1,dirt_pile_1,vid_camera_1,observer_1,running_man_1,ied_box_1,ied_supply_man_1,odd_drums_1,vbied_van_1,ied_patch_1,burkha_girl_1,ruined_house_1,broken_wall_2,bad_trash_pile_1,broken_wall_ied_1,broken_guardrail_1,bad_curb_1,reporter_1,bad_bag_pile_1,
bad_barrels_1,bad_rubble_1,broken_fence_no_ip_1,buried_tank_1,new_containers_1,poster_wall_1,concrete_ied_1,bad_mixer_1];

_blank = ““;

totalClicks = 0;

totalCorrect = 0;

scoreL = 0;

scoreM = 0;

scoreH = 0;

clickL = 0;

clickM = 0;

clickH = 0;

_filename = “targetsFound.txt”;

```
_filename2 = "headDirection.txt";
_filename3 = "clicked.txt";
_filename4 = "startTimes.txt";
_append = format["Write(%1)@%2,"_filename,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename2,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename3,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
_append = format["Write(%1)@%2,"_filename4,_blank];
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
```

hint "This is Session 3 of the 3rd week for your training. Today you will again identify changes according to your confidence level that something has changed. Remember that misses count against your score so you should have some level of confidence that something has changed before pressing a key. Press 1 then 9 to begin the patrol.";

```
playSound "welcomeDayThree";
while {alive player} do
{
    _headDir = getDir player;
    _vehDir = getDir veh_1;
    _relDir = _headDir - _vehDir;
    _time = time;
```

_append = format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

sleep 0.2;

};

10. Session 10

_blank = ““;

_filename2 = “headDirection.txt”;

_append = format[“Write(%1)@%2,”_filename2,_blank];

_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];

hint “Welcome to your last week of Change Detection Training. This is your first session of three sessions for this week. Like last week, in this first session you will be exposed to the baseline environment. It is exactly the same baseline that you saw in the last three weeks’ first session. Therefore, today your task is simply to observe the environment so that you are prepared to identify changes in the next two sessions. You will not be clicking or pressing H, M, or L for anything today. When you are ready to begin, press 1 then 9.”;

playSound “weekTwoSessionOne”;

while {alive player} do

{

_headDir = getDir player;

_vehDir = getDir veh_1;

_relDir = _headDir - _vehDir;

_time = time;

```
_append =
format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];
			_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
			sleep 0.2;
		};
```

11. Session 11

```
0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;
0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;
0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;
myArray = [];
_blank = ““;
totalClicks = 0;
totalCorrect = 0;
scoreL = 0;
scoreM = 0;
scoreH = 0;
clickL = 0;
clickM = 0;
clickH = 0;
_filename = “targetsFound.txt”;
_filename2 = “headDirection.txt”;
_filename3 = “clicked.txt”;
_filename4 = “startTimes.txt”;
```

```
_append = format[“Write(%1)@%2,”_filename,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename2,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename3,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename4,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
hint “Welcome to day two of the last week of Change Detection Training. In your last session, you were allowed to observe the baseline environment.  In today’s session, you will attempt to identify any changes from that baseline environment.  Use the H, M, and L keys to indicate your confidence level when identifying a suspected change. Remember that misses count against your score so you should have some level of confidence that something has changed before pressing a key.”;
playSound “welcomeDayTwo”;
sleep 28;
hint “Now, press 1 then 9 to start your patrol up Route Blue”;
playSound “oneNine”;
while {alive player} do
{
	_headDir = getDir player;
	_vehDir = getDir veh_1;
	_relDir = _headDir - _vehDir;
	_time = time;
```

```
        _append =
format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];
        _writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
        sleep 0.2;
    };
```

12. Session 12

```
0x2E bindKey “nul = [] execVM ‘lookat1.sqf’”;
0x2F bindKey “nul = [] execVM ‘lookat2.sqf’”;
0x30 bindKey “nul = [] execVM ‘lookat3.sqf’”;
0x15 bindKey “nul = [] execVM ‘yes.sqf’”;
0x16 bindKey “nul = [] execVM ‘no.sqf’”;
myArray =
[fridge_no_play,truck_wreck,suicide_bomber,dead_body,bomb_maker,new_rock,
new_van,boarded_up_shop,weird_dudes,bomb_car,press_man,back_to_back_v
ans,UN_sacks,ice_cream_dude,bad_pile,new_boxes_no_phone_booth,new_trac
tor,new_car_open_street,nobody_ia_cp,broken_wall,jingle_truck,turned_truck,ne
w_rubble_no_kids,
wall_truck,ip_suicide_bomber,propane_tanks,bad_cart,van_bomb,new_cars,new
_barrels];
_blank = ““;
totalClicks = 0;
totalCorrect = 0;
scoreL = 0;
scoreM = 0;
```

```
scoreH = 0;
clickL = 0;
clickM = 0;
clickH = 0;
_filename = “targetsFound.txt”;
_filename2 = “headDirection.txt”;
_filename3 = “clicked.txt”;
_filename4 = “startTimes.txt”;
_filename5 = “survey.txt”;
_append = format[“Write(%1)@%2,”_filename,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename2,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename3,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename4,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
_append = format[“Write(%1)@%2,”_filename5,_blank];
_writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
```

hint “This is Session 3 and the last session for this week. Like your last session, in today’s session you will be asked to identify changes according to your confidence level. Identify any changes you see from the baseline environment you observed in the first session this week. Press 1 then 9 when you are ready to begin”;

```
playSound “welcomeDayThree”;
sleep 22;
while {alive player} do
{
    _headDir = getDir player;
    _vehDir = getDir veh_1;
    _relDir = _headDir - _vehDir;
    _time = time;
    _append =
format[“AppendLine(%1)@%2,%3,”_filename2,_relDir,_time];
    _writeFile = pluginFunction [“VBSPluginFileAccess” , _append];
    sleep 0.2;
};
```

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APPENDIX G. VBS2™ VOICEOVER SCRIPTS

A. SCENARIO SCRIPTS

1. Session 1

"Aim at the Yellow Cross. This is the maximum distance at which the system will allow you to identify changes. The Green Arrows represent the maximum allowable azimuth error."

"In this scenario today, you will not be identifying changes. You are to conduct observation as the gunner during the patrol. Move your mouse to rotate your view. Learn this environment. In the next two sessions, you will be required to identify things that have changed from the environment you see today."

"Every session's patrol route will be the same. It will last approximately 12 minutes. We will follow Route Blue, straight ahead of you. Then, we will make a right turn on Route Red. Then, when we reach Route Green at Victory Bridge, we will take another right and follow Route Green along the river. At the end of Route Green, we will make a right turn onto Route Purple for the final portion of our patrol. Again, every session's patrol will follow this same route."

"Again, it is important to understand that today's session exposes you to the base or baseline environment. You will be required in the other two sessions of this week to identify changes from this environment you see today. As we proceed with the training, you will see this baseline environment as the first session of every week."

"Now, press 1 then 9 to start your patrol up Route Blue"

2. Session 2

“Welcome to day two of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today’s session, you will attempt to identify any changes from that baseline environment. Please be patient and listen closely as I share some important instructions.”

“To identify changes, you will aim the gun at the location and then press the key labeled H, M, or L according to your confidence level that something has changed from the baseline session -- High Confidence, Mid-Level Confidence, Low Confidence, respectively.”

“Remember from the instruction sheet you received, that the target you want to identify must be within 50 meters of your location and within a 15 degree cone for the system to register a hit, even if it is an actual change. Displayed right now for your understanding are green arrows ahead of you on the road displaying the limits of this area. If you try to identify a target outside these parameters, it will not register as a hit and will in fact register as a miss. Misses will count against your total score. It is best to wait until you have the location you want to target reasonably close before pressing the desired key.”

“I will now remove the arrows”

“If you have identified an actual change within the specified parameters, you will hear a short ding confirming the hit. If you press a button while targeting anything else, or are outside the parameters, you will hear nothing. Do not get frustrated, you have only seen the baseline once so far in this first week of training. Just continue to learn the baseline environment better each time you see it as the first session of a week.”

“There is a white pick-up truck to the right of the road ahead of you. Go ahead and aim at the truck with your gun and press the key labeled H to attempt to identify it as a change with high confidence. You will not hear any confirmation sounds, because the truck is too far away. In a few minutes, after we have started moving and are a little closer, I will ask you again to attempt to identify the truck."

"Today's patrol will follow the same route as your last session and as seen on the map at your training station. Identify any changes from the baseline environment during this 12-minute patrol."

"Now, press 1 then 9 to start your patrol up Route Blue"

"Ok, you should be close enough to identify the truck. We are highly confident of the change, so press the key labeled "H" while aiming at the truck to indicate you are highly confident that the truck is a change"

"You should hear a confirmation "ding" which indicates that was a correct detection"

"You will now conduct the patrol. Identify any changes you may see. Good luck."

3. Session 3

"Welcome to day three of Change Detection Training. In session one, you observed the baseline environment. In your last session, you attempted to identify changes in the environment. It was likely a little frustrating since the environment is still so new to you. However, with each session you should become more accustomed to the sights and activity of the patrol area. Today, you will have another opportunity to identify changes from the baseline environment that you observed during the first session of this week."

"As a reminder, to identify changes, you will aim the gun at the location and then press the key labeled H, M, or L according to your confidence level that something has changed from the baseline session -- High Confidence, Mid-Level Confidence, Low Confidence, respectively."

"Remember from the instruction sheet you received, that the target you want to identify must be within 50 meters of your location and within a 15 degree cone for the system to register a hit, even if it is an actual change. If you have identified an actual change within the specified parameters, you will hear a short sound confirming the hit. If you press a button while targeting anything else that is not a change, or are outside the parameters, you will hear nothing."

"Today's patrol will follow the same route as your last session and as seen on the map at your training station. Identify any changes from the baseline environment during this 12-minute patrol. You may now begin your patrol up Route Blue by pressing 1 then 9. Good Luck"

4. Session 4

"Welcome to the second week of Change Detection Training. This is your first session of three sessions for this week. Like last week, in this first session you will be exposed to the baseline environment. It is exactly the same baseline that you saw in last week's first session. Therefore, today your task is simply to observe the environment so that you are prepared to identify changes in the next two sessions. You will not be clicking or pressing H, M, or L for anything today. When you are ready to begin, press 1 then 9."

5. Session 5

"Welcome to day two of week 2 of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today's session, you will attempt to identify any changes from that baseline environment. Use the H, M, and L keys to indicate your confidence level when identifying a suspected change."

"Now, press 1 then 9 to start your patrol up Route Blue"

6. Session 6

"This is Session 3 and the last session for this week. Like your last session, in today's session you will be asked to identify changes according to your confidence level. Identify any changes you see from the baseline environment you observed in the first session this week. Press 1 then 9 when you are ready to begin”

7. Session 7

“Welcome to the third week of Change Detection Training. This is your first session of three sessions for this week. Like last week, in this first session you will be exposed to the baseline environment. It is exactly the same baseline that you saw in the last two weeks’ first session. Therefore, today your task is simply to observe the environment so that you are prepared to identify changes in the next two sessions. You will not be clicking or pressing H, M, or L for anything today. When you are ready to begin, press 1 then 9.”

8. Session 8

“Welcome to day two of week 3 of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today’s session, you will attempt to identify any changes from that baseline environment. Use the H, M, and L keys to indicate your confidence level when identifying a suspected change. Remember that misses count against your score so you should have some level of confidence that something has changed before pressing a key.”

“Now, press 1 then 9 to start your patrol up Route Blue”

9. Session 9

“This is Session 3 of the 3rd week for your training. Today you will again identify changes according to your confidence level that something has changed. Remember that misses count against your score so you should have some level of confidence that something has changed before pressing a key. Press 1 then 9 to begin the patrol.”

10. Session 10

"Welcome to your last week of Change Detection Training. This is your first session of three sessions for this week. Like last week, in this first session you will be exposed to the baseline environment. It is exactly the same baseline that you saw in the last three weeks' first session. Therefore, today your task is simply to observe the environment so that you are prepared to identify changes in the next two sessions. You will not be clicking or pressing H, M, or L for anything today. When you are ready to begin, press 1 then 9."

11. Session 11

"Welcome to day two of the last week of Change Detection Training. In your last session, you were allowed to observe the baseline environment. In today's session, you will attempt to identify any changes from that baseline environment. Use the H, M, and L keys to indicate your confidence level when identifying a suspected change. Remember that misses count against your score so you should have some level of confidence that something has changed before pressing a key."

"Now, press 1 then 9 to start your patrol up Route Blue"

12. Session 12

"This is Session 3 and the last session for this week. Like your last session, in today's session you will be asked to identify changes according to your confidence level. Identify any changes you see from the baseline environment you observed in the first session this week. Press 1 then 9 when you are ready to begin"

B. TUTORIAL SCRIPTS

1. Week 1 Baseline Tutorial

“Welcome to a short tutorial for Change Detection training”

“Recognizing change in a complex environment can be difficult but it is an important skill for soldiers or marines operating in the same dangerous neighborhoods day after day. Some changes may be indicators of a threat, some changes may be significant to report as measures of operational effectiveness in an area”

“In this tutorial, you will first be exposed to a baseline situation. I will give you pointers and hints on what to observe. Then, we will load a new scenario with changes which I will help you identify.”

“First, note the two men to your right and what they are wearing”

“Look at the vehicle to your left and note the color and type”

“Note the build-up of something at the edge of the building to the left”

“Note the behavior of the man with the vest ahead of you in the road”

“Note the fridge standing to your right”

“Note the three plants on the wall to the left”

“Note the donkey and the cart in the garage to the right”

“Note the nature of the box in a strange spot on your left and the people standing near it”

“Now let’s close this scenario and load one up with changes and see what we can identify”

2. Week 1 Change Tutorial

“Ok, now things have changed.”

“Remember the two men on the right? That has changed, right? Now there is some important looking person in the neighborhood”

“Look at the vehicle to your left and notice it has changed. Could a large truck like this indicate something?”

“See the new fuel can at the edge of the building to the left? That could be an indicator of an immediate threat.”

“Notice that the man with the vest is now displaying different behavior? Dramatic changes in a person’s behavior may indicate a more important but less visible change.”

“Note the fridge is busted on your right. If someone tampered with it, it could be dangerous”

“Note the three plants on the wall to the left are gone and different objects are there. Sometimes small changes warrant closer inspection.”

“Look, the donkey is dead and new objects are in the cart. Sometimes there are multiple associated indicators of a problem”

“Note the box is now a possible immediate threat. Another key change here is that the people there previously are not around anymore. They probably know to stay away! Many times, when something or someone is missing from the scene, you need to look for other changes”

“This concludes the tutorial. You should have a better understanding of what kind of changes to look for. Memory is a function of attention. The most important thing you can do to ensure you will recognize change is to mentally note a number of key locations in a neighborhood while on patrol. As you spend more time in the neighborhood, you can increase your awareness of what normal may look like. You will then be better at identifying changes which may indicate threats or other significant events.”

3. Week 3 Baseline Tutorial

"This is the second tutorial session for change detection training. You have some experience now, at least within a virtual environment identifying change. For this brief tutorial I will again show you some ways to identify changes in your environment. You have likely discovered that memory is critical to identifying changes. You have also learned that memory is a function of attention. But, attention is a limited resource. So how should we best direct our attention when observing our environment?"

"As you have discovered, even this virtual depiction of a typical Middle Eastern neighborhood is cluttered with endless things to pay attention to. However, one of the best indicators that something is amiss, or that something is different, is the local population. They definitely know when something has changed around them, especially if it relates to some kind of threat. Other than the local population and their behavior, you should pay attention to significant infrastructure, where the local law enforcement are positioning themselves, or even change in activity in commercial areas."

"We see we are starting in a residential area. Notice a few people in the homes around but that it mostly looks vacant."

"Look to the left and the electrical station. There doesn't seem to be any activity. You should remember that, this may be affecting power supply in the area."

"Look to the area to your right. It would be almost impossible to remember the position, type, and color of all that clutter. However, note the two kids hanging out. That should be easy to commit to memory."

"Look ahead at the traffic pattern of the vehicles. They obviously feel comfortable using that route."

"Look at the vehicles and general activity of the shipping area to your left. Just take note that there is some, maybe just a little, but some commercial activity."

"We will now exit this baseline scenario and load the changed scenario."

4. Week 3 Change Tutorial

"Now, we will look at some changes."

"You can see that there is now more activity in the neighborhood. In terms of what we could clearly identify as representative of this change with some confidence, is the party going on in the house to the left. This increase in neighborhood activity could be a positive indicator that security is improved."

"Now we see what looks like repair activity going on at the power station. This may mean that security has improved enough for the city to start reestablishing infrastructure. This is an important measure of our operational effectiveness in the area."

"Look to your right. We chose to remember the two kids. Well, they aren't there anymore. If we use this as a clue, we can look a little closer and see the disturbed earth near the refrigerator which may indicate a threat. This might be why the kids are not hanging out any more."

"Look ahead at the traffic pattern of the vehicles. They obviously no longer feel comfortable using that route. If we use this as an indicator, we might see the concrete block near the trash pile on the left which could be a threat."

"There seems to be increased activity in the shipping yard. We could identify the tractor truck as a significant change."

"This ends the last tutorial. Since attention is a limited resource, remember to use it wisely. Rather than attempt to remember every specific thing, think more about the patterns of life in the area and what those changes may mean."

APPENDIX H. JMP RAW DATA BY PARTICIPANT

A. EXPERIMENTAL DATA

	Age	Gender	Service Branch	Rank	Computer Video Games	FPS Games	Gamer ?	Ground Combat ...	Computer Based Training	Group
1	37	Male	Navy	O4	No	Days	Yes	No	Moderately Agree	No Training
2	38	Male	Army	O4	Yes	Weeks	Yes	Yes	Strongly Agree	Training
3	35	Male	Marine	O4	Yes	Years	No	Yes	Strongly Disagree	No Training
4	29	Male	Navy	O3	No	N/A	Yes	No	Strongly Disagree	No Training
5	34	Male	Internation	O4	Yes	Hours	No	No	Moderately Agree	Training
6	39	Male	Navy	O4	No	N/A	No	No	No Opinion	Training
7	41	Male	Army	O4	Yes	Years	Yes	No	Strongly Agree	No Training
8	28	Male	Air Force	O3	No	Years	No	No	Moderately Agree	No Training
9	30	Male	Army	O3	No	N/A	No	Yes	Moderately Agree	Training
10	32	Male	Navy	O3	No	Hours	No	No	Moderately Agree	Training
11	39	Male	Air Force	O4	Yes	Hours	No	No	Moderately Agree	Training
12	39	Male	Marine	O4	Yes	Weeks	Yes	No	Strongly Agree	No Training
13	28	Male	Internation	O2	Yes	Months	No	No	Moderately Agree	No Training
14	29	Male	Navy	O3	Yes	Years	Yes	No	Moderately Agree	Training
15	32	Male	Navy	O3	Yes	Days	Yes	No	Moderately Agree	No Training

Figure 32. JMP raw data: participant demographics

	Week 1: Avg Time Btw	Week 2: Avg Time Btw	Week 3: Avg Time Btw	Week 4: Avg Time Btw	Time 1-2	Time 2-3	Time 3-4	Time 4-5	Time 5-6	Time 6-7	Time 7-8	Time 8-9	Time 9-10	Time 10-11	Time 11-12	Avg Time Btw
1	24:30	22:38	24:00	24:00	27:00	22:00	:4:02:00	21:00	24:15	:4:23:45	24:00	24:00	:5:00:00	24:00	24:00	23:47
2	22:38	22:38	22:38	35:53	23:30	21:45	:5:02:45	23:15	22:00	:5:02:45	23:15	22:00	:3:03:00	48:05	23:40	25:56
3	23:00	23:15	21:38	23:53	20:30	25:30	:5:02:15	21:00	25:30	:5:01:15	19:20	23:55	:4:00:45	24:40	23:05	22:56
4	34:55	36:15	24:00	23:23	46:00	23:50	:4:01:55	48:15	24:15	:3:23:30	22:00	26:00	:5:00:00	21:50	24:55	29:38
5	24:00	24:00	24:00	24:00	24:00	24:00	:5:00:00	24:00	24:00	:5:00:00	24:00	24:00	:5:00:00	24:00	24:00	24:00
6	34:08	34:00	48:45	24:00	24:15	44:00	:4:03:45	24:30	43:30	:4:04:30	26:05	71:25	:2:22:00	24:15	23:45	35:13
7	23:45	24:00	23:03	32:58	23:45	23:45	:5:00:15	24:15	23:45	:4:23:40	22:50	23:15	:5:02:15	48:05	17:50	25:56
8	24:00	24:00	23:58	22:45	24:00	24:00	:5:00:00	23:00	25:00	:4:00:00	24:00	23:55	:5:02:35	21:20	24:10	23:41
9	24:00	24:00	24:00	22:13	24:00	24:00	:5:00:00	24:00	24:00	:6:00:00	24:00	24:00	:3:23:50	24:10	20:15	23:33
10	36:00	24:03	23:35	23:45	48:00	24:00	:3:23:45	24:15	23:50	:5:00:55	23:10	24:00	:5:00:05	24:00	23:30	26:51
11	33:53	23:45	23:45	25:38	43:45	24:00	:5:04:15	24:00	23:30	:3:23:45	22:40	24:50	:0:20:00	27:30	23:45	26:45
12	24:05	24:00	22:13	23:50	24:30	23:40	:6:00:05	23:45	24:15	:4:21:05	20:40	23:45	:4:03:15	23:45	23:55	23:32
13	24:00	24:00	23:08	23:38	24:10	23:50	:5:00:00	24:00	24:00	:4:01:50	22:55	23:20	:6:01:25	23:25	23:50	23:41
14	11:50	20:55	33:30	13:30	19:10	4:30	:6:00:15	23:00	18:50	:4:05:25	43:15	23:45	:3:23:15	3:10	23:50	19:56
15	22:15	22:38	24:15	25:25	19:45	24:45	:5:02:30	20:45	24:30	:3:23:30	27:45	20:45	:5:00:15	25:35	25:15	23:38

Figure 33. JMP raw data: participant times between sessions

	Session 1: DTG	Session 2: DTG	Session 3: DTG	Session 4: DTG	Session 5: DTG	Session 6: DTG	Session 7: DTG	Session 8: DTG	Session 9: DTG	Session 10: DTG	Session 11: DTG	Session 12: DTG
1	2011-05-04T10:00	2011-05-05T13:00	2011-05-06T11:00	2011-05-10T13:00	2011-05-11T10:0	2011-05-12T10:15	2011-05-17T10:00	2011-05-18T10:00	2011-05-19T10:00	2011-05-24T10:00	2011-05-25T10:00	2011-05-26T10:00
2	2011-05-04T14:00	2011-05-05T13:30	2011-05-06T11:15	2011-05-11T14:00	2011-05-12T13:1	2011-05-13T11:15	2011-05-18T14:00	2011-05-19T13:15	2011-05-20T11:15	2011-05-23T14:15	2011-05-25T14:20	2011-05-26T14:00
3	2011-05-04T15:00	2011-05-05T11:30	2011-05-06T13:00	2011-05-11T15:15	2011-05-12T12:1	2011-05-13T13:45	2011-05-18T15:00	2011-05-19T10:20	2011-05-20T10:15	2011-05-24T11:00	2011-05-25T11:40	2011-05-26T10:45
4	2011-05-10T12:00	2011-05-12T10:00	2011-05-13T09:50	2011-05-17T11:45	2011-05-19T12:0	2011-05-20T12:15	2011-05-24T11:45	2011-05-25T09:45	2011-05-26T11:45	2011-05-31T11:45	2011-06-01T09:35	2011-06-02T10:30
5	2011-05-10T13:45	2011-05-11T13:45	2011-05-12T13:45	2011-05-17T13:45	2011-05-18T13:4	2011-05-19T13:45	2011-05-24T13:45	2011-05-25T13:45	2011-05-26T13:45	2011-05-31T13:45	2011-06-01T13:45	2011-06-02T13:45
6	2011-05-10T14:00	2011-05-11T14:15	2011-05-13T10:15	2011-05-17T14:00	2011-05-18T14:3	2011-05-20T10:00	2011-05-24T14:30	2011-05-25T16:35	2011-05-28T16:00	2011-05-31T14:00	2011-06-01T14:15	2011-06-02T14:00
7	2011-05-10T14:45	2011-05-11T14:30	2011-05-12T14:15	2011-05-17T14:30	2011-05-18T14:4	2011-05-19T14:30	2011-05-24T14:10	2011-05-25T13:00	2011-05-26T12:15	2011-05-31T14:30	2011-06-02T14:35	2011-06-03T08:25
8	2011-05-11T13:30	2011-05-12T13:30	2011-05-13T13:30	2011-05-18T13:30	2011-05-19T12:3	2011-05-20T13:30	2011-05-24T13:30	2011-05-25T13:30	2011-05-26T13:25	2011-05-31T16:00	2011-06-01T13:20	2011-06-02T13:30
9	2011-05-16T13:00	2011-05-17T13:00	2011-05-18T13:00	2011-05-23T13:00	2011-05-24T13:0	2011-05-25T13:00	2011-05-31T13:00	2011-06-01T13:00	2011-06-02T13:00	2011-06-06T12:50	2011-06-07T13:00	2011-06-08T09:15
10	2011-05-17T08:45	2011-05-19T08:45	2011-05-20T08:45	2011-05-24T08:30	2011-05-25T08:4	2011-05-26T08:35	2011-05-31T09:30	2011-06-01T08:40	2011-06-02T08:40	2011-06-07T08:45	2011-06-08T08:45	2011-06-09T08:15
11	2011-05-23T14:45	2011-05-25T10:30	2011-05-26T10:30	2011-05-31T14:45	2011-06-01T14:4	2011-06-02T14:15	2011-06-06T14:00	2011-06-07T12:40	2011-06-08T13:30	2011-06-09T09:30	2011-06-10T13:00	2011-06-11T12:45
12	2011-05-23T15:00	2011-05-24T15:30	2011-05-25T15:10	2011-05-31T15:15	2011-06-01T15:0	2011-06-02T15:15	2011-06-07T12:20	2011-06-08T09:00	2011-06-09T08:45	2011-06-13T12:00	2011-06-14T11:45	2011-06-15T11:40
13	2011-05-24T11:15	2011-05-25T11:25	2011-05-26T11:15	2011-05-31T11:15	2011-06-01T11:1	2011-06-02T11:15	2011-06-06T13:05	2011-06-07T12:00	2011-06-08T11:20	2011-06-14T12:45	2011-06-15T12:10	2011-06-16T12:00
14	2011-05-24T15:05	2011-05-25T10:15	2011-05-25T14:45	2011-05-31T15:00	2011-06-01T14:0	2011-06-02T08:50	2011-06-06T14:15	2011-06-08T09:30	2011-06-09T09:15	2011-06-13T08:30	2011-06-13T11:40	2011-06-14T11:30
15	2011-05-24T16:30	2011-05-25T12:15	2011-05-26T13:00	2011-05-31T15:30	2011-06-01T12:1	2011-06-02T12:45	2011-06-06T12:15	2011-06-07T16:00	2011-06-08T12:45	2011-06-13T13:00	2011-06-14T14:35	2011-06-15T15:50

Figure 34. JMP raw data: participant experiment times

	Session 2: FA Clicks	Session 2: Low Confidence	Session 2: Med Confidence	Session 2: High Confidence	Session 3: Hits	Session 3: FA	Session 3: Clicks	Session 3: Hits - Low...	Session 3: Hits - Med...	Session 3: Hits - High..	Session 3: FA - Low...	Session 3: FA - Med...	Session 3: FA - High...	Session 3: Clicks - Low...	Session 3: Clicks - Med	Session 3: Clicks - High
1	39	28	7	4	13	15	28	2	5	6	6	3	6	8	8	12
2	130	1	85	44	9	60	69	0	0	9	0	9	51	0	9	60
3	29	0	19	10	17	18	35	0	8	9	0	3	15	0	11	24
4	19	19	0	0	26	129	155	26	0	0	129	0	0	155	0	0
5	20	13	7	0	21	21	42	6	5	10	13	4	4	19	9	14
6	14	8	6	0	18	18	36	9	8	1	16	2	0	25	10	1
7	16	0	3	13	7	9	16	0	2	5	0	7	2	0	9	7
8	41	19	12	10	22	30	52	6	0	16	22	0	8	28	0	24
9	16	13	3	0	18	22	40	7	5	6	14	5	3	21	10	9
10	27	0	7	20	10	24	34	0	0	10	0	0	24	0	0	34
11	14	6	7	1	15	15	30	1	2	12	4	5	6	5	7	18
12	8	5	2	1	11	4	15	3	3	5	3	0	1	6	3	6
13	39	2	18	19	16	28	44	1	7	8	4	15	9	5	22	17
14	32	27	1	4	18	19	37	7	2	9	11	1	7	18	3	16
15	4	2	2	0	11	22	33	7	4	0	16	5	1	23	9	1

Figure 35. JMP raw data: Sessions 2 and 3 (week 1)

	Session 5: FA Clicks	Session 5: Low Confidence	Session 5: Med Confidence	Session 5: High Confidence	Session 6: Hits	Session 6: FA	Session 6 Clicks	Session 6: Hits - Low...	Session 6: Hits - Med..	Session 6: Hits - High..	Session 6: FA - Low..	Session 6: FA - Med...	Session 6: FA - High..	Session 6: Clicks - Low..	Session 6: Clicks - Med.	Session 6: Clicks - High
1	9	6	0	3	22	4	26	4	3	15	3	1	0	7	4	15
2	36	8	9	19	18	46	64	0	0	18	0	0	46	0	0	64
3	10	1	1	8	20	15	35	1	1	18	2	1	12	3	2	30
4	36	36	0	0	18	40	58	10	1	7	31	8	1	41	9	8
5	14	8	2	4	21	17	38	2	1	18	5	2	10	7	3	28
6	12	10	2	0	27	23	50	3	7	17	13	4	6	16	11	23
7	9	0	2	7	16	8	24	2	1	13	4	1	3	6	2	16
8	14	11	2	1	25	18	43	3	0	22	12	0	6	15	0	28
9	3	2	0	1	17	9	26	6	5	6	2	5	2	8	10	8
10	11	2	0	9	20	14	34	7	0	13	2	2	10	9	2	23
11	3	1	0	2	23	12	35	1	2	20	4	1	7	5	3	27
12	5	3	2	0	15	11	26	4	2	9	9	0	2	13	2	11
13	3	1	1	1	24	18	42	3	1	20	6	2	10	9	3	30
14	20	15	0	5	20	12	32	1	4	15	3	3	6	4	7	21
15	13	4	8	1	23	13	36	2	5	16	6	4	3	8	9	19

Figure 36. JMP raw data: Sessions 5 and 6 (week 2)

	Session 8: FA Clicks	Session 8: Low Confidence	Session 8: Med Confidence	Session 8: High Confidence	Session 9: Hits	Session 9: FA	Session 9: Clicks	Session 9: Hits - Low..	Session 9: Hits - Med..	Session 9: Hits - High..	Session 9: FA - Low..	Session 9: FA - Med..	Session 9: FA - High..	Session 9: Clicks - Low..	Session 9: Clicks - Med	Session 9: Clicks - High
1	11	11	0	0	24	15	39	3	0	21	11	0	4	14	0	25
2	16	3	1	12	24	26	50	0	0	24	2	0	24	2	0	48
3	7	0	3	4	22	9	31	0	0	22	0	1	8	0	1	30
4	7	5	0	2	24	22	46	5	0	19	16	0	6	21	0	25
5	7	5	1	1	24	22	46	2	3	19	4	6	12	6	9	31
6	9	6	3	0	26	22	48	3	6	17	5	9	8	8	15	25
7	3	3	0	0	20	5	25	6	0	14	2	0	3	8	0	17
8	10	10	0	0	26	17	43	0	0	26	7	0	10	7	0	36
9	1	1	0	0	17	6	23	2	1	14	2	2	2	4	3	16
10	5	4	1	0	15	25	40	0	3	12	0	10	15	0	13	27
11	0	0	0	0	27	8	35	0	0	27	2	1	5	2	1	32
12	3	3	0	0	23	11	34	3	3	17	7	1	3	10	4	20
13	4	1	1	2	23	19	42	0	2	21	0	8	11	0	10	32
14	10	7	1	2	24	15	39	2	5	17	11	1	3	13	6	20
15	5	1	3	1	27	11	38	2	4	21	4	4	3	6	8	24

Figure 37. JMP raw data: Sessions 8 and 9 (week 3)

	Session 11: FA Clicks	Session 11: Low Confidence	Session 11: Med Confidence	Session 11: High Confidence	Session 12: Hits	Session 12: FA	Session 12: Clicks	Session 12: Hit - Low...	Session 12: Hit - Med...	Session 12: Hit - High...	Session 12: FA - Low...	Session 12: FA - Med...	Session 12: FA - High...	Session 12: Clicks - Low...	Session 12: Clicks - Med...	Session 12: Clicks - High...
1	5	4	1	0	25	10	35	4	0	21	5	2	3	9	2	24
2	3	1	2	0	23	29	52	0	1	22	6	0	23	6	1	45
3	2	0	1	1	19	9	28	0	0	19	0	0	9	0	0	28
4	2	2	0	0	20	13	33	5	3	12	9	0	4	14	3	16
5	2	0	0	2	23	14	37	1	2	20	2	2	10	3	4	30
6	4	4	0	0	27	13	40	1	3	23	5	6	2	6	9	25
7	8	6	0	2	16	1	17	1	0	15	1	0	0	2	0	15
8	3	3	0	0	28	8	36	0	0	28	5	0	3	5	0	31
9	0	0	0	0	21	5	26	3	2	16	2	1	2	5	3	18
10	12	5	7	0	21	24	45	7	1	13	9	0	15	16	1	28
11	0	0	0	0	25	7	32	3	0	22	2	0	5	5	0	27
12	7	6	0	1	20	10	30	2	6	12	4	2	4	6	8	16
13	2	1	1	0	27	12	39	0	2	25	5	0	7	5	2	32
14	3	3	0	0	25	20	45	2	1	22	11	1	8	13	2	30
15	6	3	2	1	27	8	35	2	2	23	4	3	1	6	5	24

Figure 38. JMP raw data: Sessions 11 and 12 (week 4)

	Group	Total False Alarms	Noise Only False Alarms	Signal + Noise False Alarms	Signal + Noise Hits	Signal + Noise Total Clicks	Participant's Total Clicks
1	No Training	108	64	44	84	128	192
2	Training	346	185	161	74	235	420
3	No Training	99	48	51	78	129	177
4	No Training	268	64	204	88	292	356
5	Training	117	43	74	89	163	206
6	Training	115	39	76	98	174	213
7	No Training	59	36	23	59	82	118
8	No Training	141	68	73	101	174	242
9	Training	62	20	42	73	115	135
10	Training	142	55	87	66	153	208
11	Training	59	17	42	90	132	149
12	No Training	59	23	36	69	105	128
13	No Training	125	48	77	90	167	215
14	Training	131	65	66	87	153	218
15	No Training	82	28	54	88	142	170

Figure 39. JMP raw data: total hits, FA, and clicks

B. CONFIDENCE DATA

	Participant	Session	Hits	False Alarms	Scenario	Total Clicks	Percentage Hits	Percentage FA	Low Confidence	Medium Confidence	High Confidence	FA Session	FA Clicks: Noise Only	Data Check: Hits=Conf
1	1	3	13	15	1	28	46.4286%	53.5714%	2	5	6	2	39	1
2	2	3	9	60	1	69	13.0435%	86.9565%	0	0	9	2	130	1
3	3	3	17	18	1	35	48.5714%	51.4286%	0	8	9	2	29	1
4	4	3	26	129	1	155	16.7742%	83.2258%	26	0	0	2	19	1
5	5	3	21	21	1	42	50.0000%	50.0000%	6	5	10	2	20	1
6	6	3	18	18	1	36	50.0000%	50.0000%	9	8	1	2	14	1
7	7	3	7	9	1	16	43.7500%	56.2500%	0	2	5	2	16	1
8	8	3	22	30	1	52	42.3077%	57.6923%	6	0	16	2	41	1
9	9	3	18	22	1	40	45.0000%	55.0000%	6	6	6	2	16	1
10	10	3	10	24	1	34	29.4118%	70.5882%	0	0	10	2	27	1
11	11	3	15	15	1	30	50.0000%	50.0000%	1	2	12	2	14	1
12	12	3	11	4	1	15	73.3333%	26.6667%	3	3	5	2	8	1
13	13	3	16	28	1	44	36.3636%	63.6364%	1	7	8	2	39	1
14	14	3	18	19	1	37	48.6486%	51.3514%	7	2	9	2	32	1
15	15	3	11	22	1	33	33.3333%	66.6667%	7	4	0	2	4	1
16	1	6	22	4	2	26	84.6154%	15.3846%	4	3	15	5	9	1
17	2	6	18	46	2	64	28.1250%	71.8750%	0	0	18	5	36	1
18	3	6	20	15	2	35	57.1429%	42.8571%	1	1	18	5	10	1
19	4	6	18	40	2	58	31.0345%	68.9655%	10	1	7	5	36	1
20	5	6	21	17	2	38	55.2632%	44.7368%	2	1	18	5	14	1
21	6	6	27	23	2	50	54.0000%	46.0000%	3	7	17	5	12	1
22	7	6	16	8	2	24	66.6667%	33.3333%	2	1	13	5	9	1
23	8	6	25	18	2	43	58.1395%	41.8605%	3	0	22	5	14	1
24	9	6	17	9	2	26	65.3846%	34.6154%	6	5	6	5	3	1
25	10	6	20	14	2	34	58.8235%	41.1765%	7	0	13	5	11	1
26	11	6	23	12	2	35	65.7143%	34.2857%	1	2	20	5	3	1
27	12	6	15	11	2	26	57.6923%	42.3077%	4	2	9	5	5	1
28	13	6	24	18	2	42	57.1429%	42.8571%	3	1	20	5	3	1
29	14	6	20	12	2	32	62.5000%	37.5000%	1	4	15	5	20	1
30	15	6	23	13	2	36	63.8889%	36.1111%	2	5	16	5	13	1
31	1	9	24	15	1	39	61.5385%	38.4615%	3	0	21	8	11	1
32	2	9	24	26	1	50	48.0000%	52.0000%	0	0	24	8	16	1
33	3	9	22	9	1	31	70.9677%	29.0323%	0	0	22	8	7	1
34	4	9	24	22	1	46	52.1739%	47.8261%	5	0	19	8	7	1
35	5	9	24	22	1	46	52.1739%	47.8261%	2	3	19	8	7	1
36	6	9	26	22	1	48	54.1667%	45.8333%	3	6	17	8	9	1
37	7	9	20	5	1	25	80.0000%	20.0000%	6	0	14	8	3	1
38	8	9	26	17	1	43	60.4651%	39.5349%	0	0	26	8	10	1
39	9	9	17	6	1	23	73.9130%	26.0870%	2	1	14	8	1	1
40	10	9	15	25	1	40	37.5000%	62.5000%	0	3	12	8	5	1
41	11	9	27	8	1	35	77.1429%	22.8571%	0	0	27	8	0	1
42	12	9	23	11	1	34	67.6471%	32.3529%	3	3	17	8	3	1
43	13	9	23	19	1	42	54.7619%	45.2381%	0	2	21	8	4	1
44	14	9	24	15	1	39	61.5385%	38.4615%	2	5	17	8	10	1
45	15	9	27	11	1	38	71.0526%	28.9474%	2	4	21	8	5	1
46	1	12	25	10	2	35	71.4286%	28.5714%	4	0	21	11	5	1
47	2	12	23	29	2	52	44.2308%	55.7692%	0	0	23	11	3	1
48	3	12	19	9	2	28	67.8571%	32.1429%	0	0	19	11	2	1
49	4	12	20	13	2	33	60.6061%	39.3939%	5	3	12	11	2	1
50	5	12	23	14	2	37	62.1622%	37.8378%	1	2	20	11	2	1
51	6	12	27	13	2	40	67.5000%	32.5000%	1	2	24	11	4	1
52	7	12	16	1	2	17	94.1176%	5.8824%	1	0	15	11	8	1
53	8	12	28	8	2	36	77.7778%	22.2222%	0	0	28	11	3	1
54	9	12	21	5	2	26	80.7692%	19.2308%	3	2	16	11	0	1
55	10	12	21	24	2	45	46.6667%	53.3333%	7	1	13	11	12	1
56	11	12	25	7	2	32	78.1250%	21.8750%	2	0	23	11	0	1
57	12	12	20	10	2	30	66.6667%	33.3333%	2	6	12	11	7	1
58	13	12	27	12	2	39	69.2308%	30.7692%	0	2	25	11	2	1
59	14	12	25	20	2	45	55.5556%	44.4444%	2	1	22	11	3	1
60	15	12	27	8	2	35	77.1429%	22.8571%	2	2	23	11	6	1

Figure 40. JMP raw data: participant detection confidence

APPENDIX I. CONFIDENCE AND THREAT RAW DATA

A. SME RATINGS OF CHANGES

The next two tables show the subject matter expert (SME) ratings for all changes in Scenario 1 and 2. The tables order the changes from lowest threat to highest threat, ordered first by the mean rating, then the lowest standard deviation of the rating. The research team put the changes into bins of 10 "low," "medium," and "high" threat.

Scenario #	Variable Name	SME 1	SME 2	SME 3	SME 4	STDEV	Average
1	burkha_girl_1	2	2	2	2	0.0000	2
1	broken_fence_no_ip_1	3	2	2	1	0.8165	2
1	ied_supply_man_1	1	2	1	4	1.4142	2
1	propane_tank_sales_1	2	2	3	2	0.5000	2.25
1	broken_wall_1	2	3	2	2	0.5000	2.25
1	broken_wall_2	2	3	2	2	0.5000	2.25
1	new_containers_1	2	4	2	1	1.2583	2.25
1	poster_wall_1	4	1	2	2	1.2583	2.25
1	dirt_pile_1	3	2	3	2	0.5774	2.5
1	bad_mixer_1	2	2	4	2	1.0000	2.5
1	ied_box_1	4	2	3	1	1.2910	2.5
1	broken_guardrail_1	4	1	3	2	1.2910	2.5
1	reporter_1	4	2	3	1	1.2910	2.5
1	burnt_truck_1	4	3	3	3	0.5000	3.25
1	observer_1	4	2	4	3	0.9574	3.25
1	vbied_van_1	4	3	2	4	0.9574	3.25
1	ied_patch_1	4	3	4	2	0.9574	3.25
1	ruined_house_1	4	4	2	3	0.9574	3.25
1	broken_wall_ied_1	2	3	4	4	0.9574	3.25
1	bad_trash_pile_1	1	4	4	4	1.5000	3.25
1	running_man_1	4	3	4	3	0.5774	3.5
1	buried_tank_1	4	4	2	4	1.0000	3.5
1	tire_1	4	4	4	3	0.5000	3.75
1	bad_curb_1	4	3	4	4	0.5000	3.75
1	bad_bag_pile_1	4	3	4	4	0.5000	3.75
1	concrete_ied_1	4	4	4	3	0.5000	3.75
1	odd_drums_1	4	4	4	4	0.0000	4
1	bad_rubble_1	2	4	5	5	1.4142	4
1	vid_camera_1	4	4	4	5	0.5000	4.25
1	bad_barrels_1	4	4	5	5	0.5774	4.5

Table 16. SME ratings for Scenario 1 changes

Scenario #	Variable Name	SME 1	SME 2	SME 3	SME 4	STDEV	Average
2	ice_cream_dude	1	1	1	2	0.5000	1.25
2	new_tractor	1	1	2	1	0.5000	1.25
2	nobody_ia_cp	2	1	1	1	0.5000	1.25
2	new_van	2	2	1	1	0.5774	1.5
2	jingle_truck	1	1	3	1	1.0000	1.5
2	weird_dudes	1	3	2	1	0.9574	1.75
2	new_cars	2	1	3	1	0.9574	1.75
2	press_man	2	2	2	2	0.0000	2
2	van_bomb	2	3	2	1	0.8165	2
2	bomb_maker	4	2	1	1	1.4142	2
2	truck_wreck	2	3	2	2	0.5000	2.25
2	new_boxes_no_phone_boot	2	2	3	3	0.5774	2.5
2	UN_sacks	4	3	2	2	0.9574	2.75
2	broken_wall	3	2	2	4	0.9574	2.75
2	new_rubble_no_kids	2	3	4	2	0.9574	2.75
2	back_to_back_vans	4	3	3	2	0.8165	3
2	new_car_open_street	3	4	3	2	0.8165	3
2	propane_tanks	2	3	4	3	0.8165	3
2	boarded_up_shop	2	2	4	4	1.1547	3
2	turned_truck	4	3	3	3	0.5000	3.25
2	wall_truck	4	2	4	3	0.9574	3.25
2	bad_cart	4	3	4	3	0.5774	3.5
2	bad_pile	2	4	4	4	1.0000	3.5
2	new_barrels	4	4	4	2	1.0000	3.5
2	new_rock	4	3	4	4	0.5000	3.75
2	dead_body	5	3	4	3	0.9574	3.75
2	fridge_no_play	4	4	4	5	0.5000	4.25
2	bomb_car	4	4	4	5	0.5000	4.25
2	suicide_bomber	5	5	5	4	0.5000	4.75
2	ip_suicide_bomber	5	5	5	5	0.0000	5

Figure 41. SME ratings for Scenario 2 changes

B. PARTICIPANT DETECTION CONFIDENCE

No Training

0007	Low	Med	High
Session 3	0	2	5
Session 6	2	1	13
Session 9	6	0	14
Session 12	1	0	15
Totals	9	3	47

0490	Low	Med	High
Session 3	3	3	5
Session 6	4	2	9
Session 9	3	3	17
Session 12	2	6	12
	12	14	43

0891	Low	Med	High
Session 3	6	0	16
Session 6	3	0	22
Session 9	0	0	26
Session 12	0	0	28
	9	0	92

1133	Low	Med	High
Session 3	0	8	9
Session 6	1	1	18
Session 9	0	0	22
Session 12	0	0	19
	1	9	68

2888	Low	Med	High
Session 3	26	0	0
Session 6	10	1	7
Session 9	5	0	19
Session 12	5	3	12
	46	4	38

3767	Low	Med	High
Session 3	7	4	0
Session 6	2	5	16
Session 9	2	4	21
Session 12	2	2	23
	13	15	60

4814	Low	Med	High
Session 3	1	7	8
Session 6	3	1	20
Session 9	0	2	21
Session 12	0	2	25
	4	12	74

9767	Low	Med	High
Session 3	2	5	6
Session 6	4	3	15
Session 9	3	0	21
Session 12	4	0	21
	13	8	63

Training

1407	Low	Med	High
Session 3	9	8	1
Session 6	3	7	17
Session 9	3	6	17
Session 12	1	2	24
	16	23	59

1822	Low	Med	High
Session 3	0	0	9
Session 6	0	0	18
Session 9	0	0	24
Session 12	0	0	23
	0	0	74

2458	Low	Med	High
Session 3	6	5	10
Session 6	2	1	18
Session 9	2	3	19
Session 12	1	2	20
	11	11	67

4395	Low	Med	High
Session 3	0	0	10
Session 6	7	0	13
Session 9	0	3	12
Session 12	7	1	13
	14	4	48

5669	Low	Med	High
Session 3	6	6	6
Session 6	6	5	6
Session 9	2	1	14
Session 12	3	2	16
	17	14	42

6849	Low	Med	High
Session 3	1	2	12
Session 6	1	2	20
Session 9	0	0	27
Session 12	2	0	23
	4	4	82

9862	Low	Med	High
Session 3	7	2	9
Session 6	1	4	15
Session 9	2	5	17
Session 12	2	1	22
	12	12	63

Figure 42. Confidence raw data by raw data

APPENDIX J. DESIGNING AND EXECUTING CHANGE DETECTION SCENARIO TRAINING

A. SCENARIO INSTRUCTIONS FOR EDITORS

- Install VBS2 VTK 1.40 or better.
- Label the “C,” “V,” and “B” keys of the keyboard “H,” “M” and “L” for ease of recognition by the participant.
- Open VBS2 by double-clicking on the desktop shortcut called “VBS2 Administrator.”
- In the bottom right of the screen, where it says “Profile,” click on the name, then click “New,” then create a new unique profile name. Click “Ok.”
- In the bottom left of the screen, click the “Options” button. In the pop-up menu that appears, select “Video Options.” Set the native resolution and aspect ratio for the monitor to be used. Click “Ok” when finished.
- Exit VBS2.
- Open the ***profile.txt*** file included in the archive on the DVD. Select the entire text and copy to the clipboard. (Edit-->Select All then Edit---> Copy)
- Navigate to the location where the unique profile (in 4 above) was created. For Win7, it will either be in ...Documents/VBS2 or in ...Documents/VBS2 Other Profiles , depending on whether this is the first profile to have been set up on VBS2 on the computer being used. Open the profile file with notepad, delete all the text in the file, then paste in all the text copied in step 7 above. Save the profile file. This ensures all settings are as intended for the change detection training. (For WinXP, these folders will be located in “My Documents”)
- Open the archive from the DVD. Extract or copy the ***mpmissions*** folder to the same location as the unique profile file. Again, this location will vary depending on whether this is the first profile created on the system or not. If the profile is the first profile to be created, this location will be ...Documents/VBS2 as seen in Figure 43.

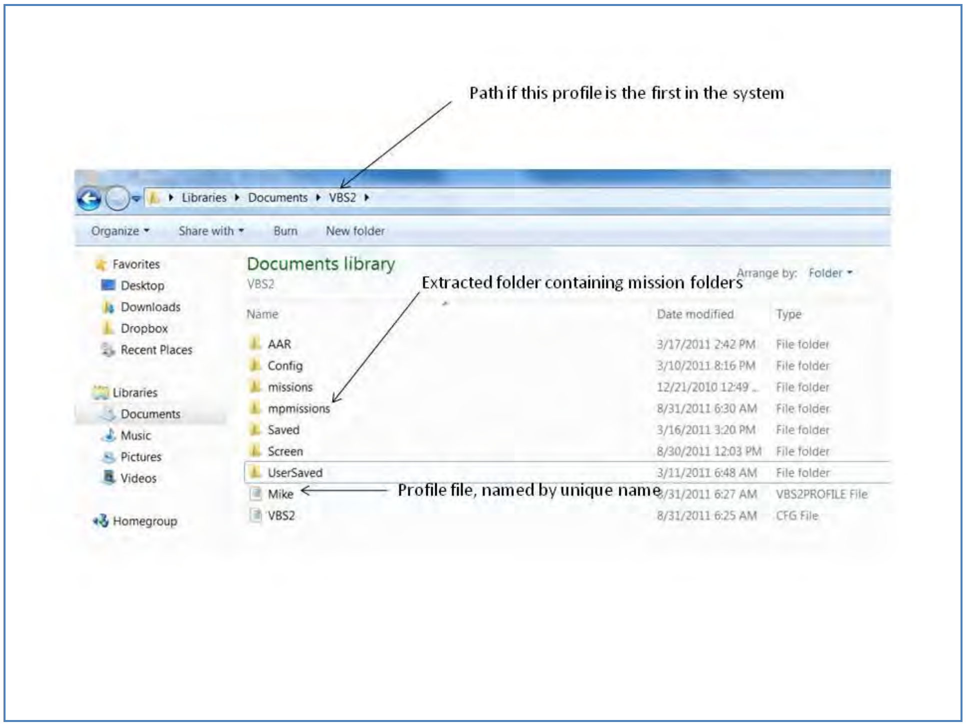

Figure 43. File view

If the profile is not the first in the system, then refer to Figure 44.

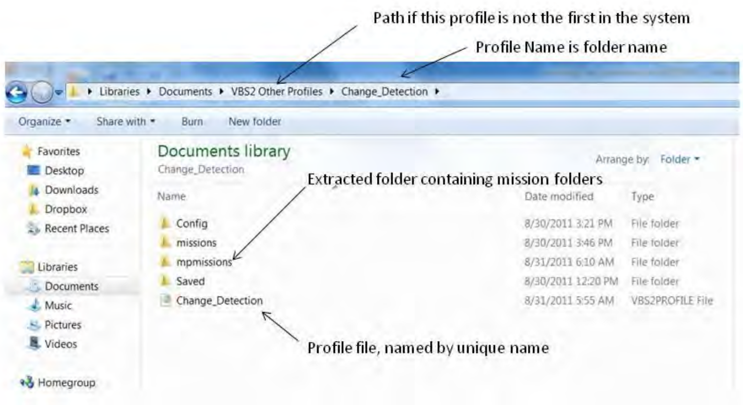

Figure 44. File view without a profile

- The mission folders in …/***mpmissions*** should include:

  Session_1.map_samawah50km_ieed

  Session_2.map_samawah50km_ieed

  Session_3.map_samawah50km_ieed

  Session_4.map_samawah50km_ieed

  Session_5.map_samawah50km_ieed

  Session_6.map_samawah50km_ieed

  Session_7.map_samawah50km_ieed

  Session_8.map_samawah50km_ieed

  Session_9.map_samawah50km_ieed

  Session_10.map_samawah50km_ieed

  Session_11.map_samawah50km_ieed

  Session_12_Training.map_samawah50km_ieed

  Session_12_Non_Training.map_samawah50km_ieed

  TrainingSession_1A.map_samawah50km_ieed

  TrainingSession_1B.map_samawah50km_ieed

TrainingSession_2A.map_samawah50km_ieed

Training2Session_2B.map_samawah50km_ieed

- Open VBS2 by double-clicking on the desktop shortcut called "VBS2 Administrator."
- Select "Mission Editor" from the main menu.
- Select "As Samawah [GAA}" and click "OK."
- Once the terrain has loaded, the 2-D editor map will be presented.
- The system is now in edit mode. Any changes will need to be saved and will overwrite the provided missions unless saved by a different name.
- In the top, left corner of the screen click File then Load.
- For the first session, select the appropriate scenario. Click "OK."
- Ensure the participant is wearing headphones or using speakers at an appropriate volume level and sitting comfortably.
- From the same "File" menu, select "Preview."
- The participant should follow all instructions given in the scenario which features voiceover instructions.
- At the conclusion of the scenario, press the "ESC" key. Click "Abort." Now, additional scenarios can be loaded and run in the same manner. However, it is critical that any data files be extracted as follows in the next step BEFORE running another scenario. If data is not extracted before running another scenario, it will be overwritten.
- All scenarios, except the training scenarios, will write to data files in the actual VBS2 root directory. If VBS2 was installed to the C drive using the default settings, this path will be C:\Bohemia Interactive\VBS2. Table 17 shows which data files should be obtained from this directory immediately after a participant has finished.

Scenario	headDirection.txt	startTimes.txt	clicked.txt	targetFinalScore.txt	targetsFound.txt	Survey.txt
1,4,7,10	√					
2,5,8,11	√	√	√	√		
3,6,9	√	√	√	√	√	
12	√	√	√	√	√	√
Training						

Table 17. Data file matrix

B. HOW TO DESIGN A CHANGE DETECTION SCENARIO

Change Detection Scenario Development Checklist:

Windows 7 was used for these instructions. Windows XP or Windows Vista will have similar operations but may not exactly match these instructions for the folder locations.

1. VBS2 custom scenario designs are, by default, saved to the folder:

My Documents/VBS2/mpmissions/*scenarioName*

2. Within this folder, there are several key files. When a scenario is saved within VBS2, this scenario folder will be created in the *mpmissions* folder. The files *mission.sqf*, *mission.biedi*, and *mission.sqm* will automatically be created within this folder. There is no need to ever open any of these mission files when designing this scenario. To create a custom scenario, the following files will be added to this scenario folder:

init.sqf - *init.sqf* is the script file which will be run automatically at the beginning of any scenario. Any procedural scripts written in this text file will be executed once at the beginning of the scenario. However, a “do while” structure can be used in the *init.sqf* file to repeat a recurring operation for the duration of the scenario. For this scenario, this file is used to bind keyboard commands to external script file execution, create data files, conduct voiceover instruction at the beginning of a scenario, and begin a “do while” loop for tracking head direction of the participant.

description.ext - *description.ext* can be used to customize the interface, but is also important for defining the sound files to be used in the scripting. For this scenario we will use it strictly to define sound files to be used in the voiceover instructions.

.sqf - A .sqf file is an external script file that will execute on command. For this scenario design, we will write several .sqf files which will be bound to keyboard commands. When a participant presses the respective key, the bound .sqf file will be executed. These .sqf files should all be created with unique names and saved within the same scenario folder as init.sqf and mission.sqf.

3. To begin creating the baseline scenario, open VBS2 by using the “VBS2 Administrator” executable.

4. On the Main Menu, select “Mission Editor.” From the list of terrain, choose “As Samawah [GAA]” and click “OK.”

5. After the terrain database loads, you will be presented with the scenario editor map. By holding down the right mouse button (RMB), the map can be scrolled when dragging the mouse. Use the mouse wheel to zoom in and out. For the design of this scenario, begin at the intersection at map coordinate 3355 8900. The map coordinates are listed as on a standard military map, with vertical and horizontal lines. The first four numbers listed are the horizontal coordinates. The last four digits are the vertical coordinates. The numbers can be seen at the extreme top and extreme left of the map.

6. First, create the HMMWV at the intersection by selecting the “Vehicle” tab (NOT the “Empty Vehicle”) in the lower right of the screen (If this is not visible, click the two-way arrow in the lower right of the screen to expand the panel).

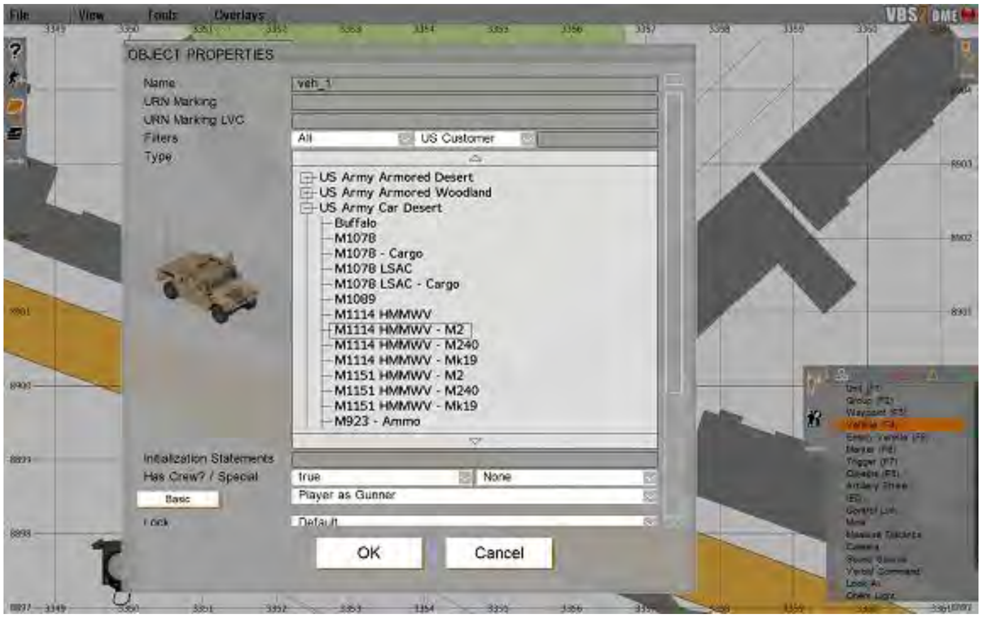

Figure 45. HMMWV creation

7. From the list, expand the “U.S. Army Car Desert” sub-list. Select “M1114 HMMWV -M2” from the list. Assign the vehicle the variable name “veh_1” by typing in the “Name” block as seen in Figure 41. Under “Has Crew? / Special” select “true,” “None,” and “Player as Gunner” as seen in Figure 45. Click “OK.”

8. To enter a 3-D view of the selected object (In this case the HMMWV), press the “M” key on the keyboard. Once in the 3-D editor, use the following commands to control the view and manipulate objects:

W, A, S, D - Horizontal translation of viewpoint

Q,Z - Vertical translation of viewpoint (Hint: higher viewpoints allow faster transition across the map).

Left-Shift - Use in combination with translation keys to move quickly around the map.

Hold RMB and move mouse - View rotation

Hold Left-Alt - Translation interface, click and drag on respective arrows to move objects in X-Y-Z plane.

Hold Left-Alt + Spacebar - Rotation Interface, Click and drag on respective circles to rotate objects in the X-Y-Z plane.

9. Using the commands, position the vehicle so it is facing northwest on the road.

Figure 46. Placing the vehicle

10. Now, create the route for the vehicle. Select the vehicle and click the RMB. From the pop-up menu, select “Assign New Waypoint.”

Figure 47. Selecting from the pop-up menu

11. Extend the waypoint to the end of the current road where it creates a "T" with the main road (the red circle in Figure 47). Click the Left Mouse Button (LMB).

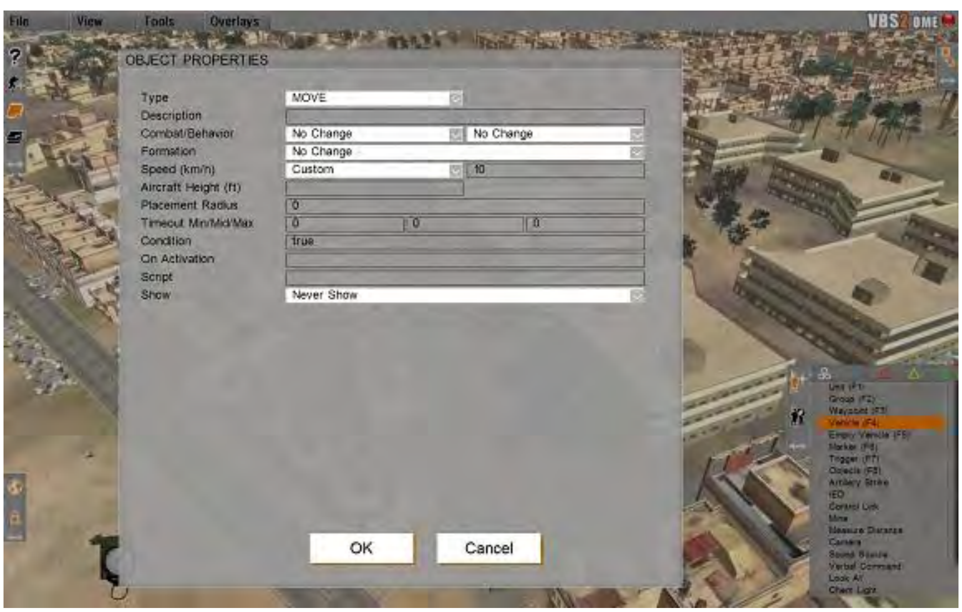

Figure 48. Waypoint object properties

12. In the Object Properties box, select “MOVE” for type, “CUSTOM” for Speed (km/h), and”10” in the box to the right (See Figure 48). This is Waypoint 1 for the vehicle. Click OK.

13. All editor operations can be performed in the 3-D Editor or 2-D Editor interface.

14. Press the “M” key to return to the 2-D Editor.

15. Select the square that represents the newly created waypoint. Click the RMB to bring up the Pop-Up menu. Select “Add New Waypoint,” extend the new waypoint and place it at the intersection in the vicinity of coordinate 3380 8965.

16. Use the same procedure described above to place two additional waypoints at the locations specified with red circles in Figure 49.

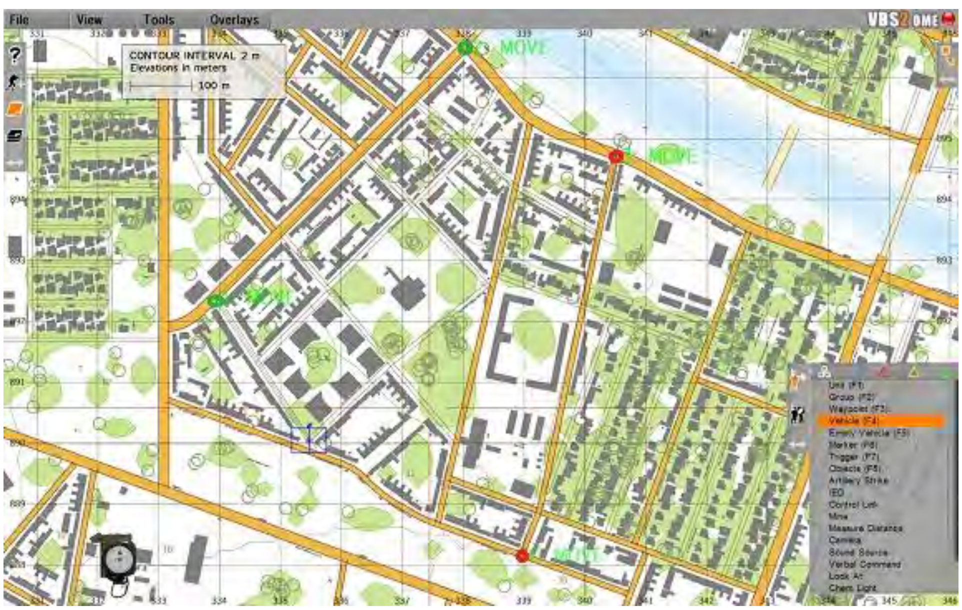

Figure 49. Adding Waypoints 3 and 4

17. Now save this scenario by clicking File -->Save. In the dialog box, enter the title of this scenario in both the “Mission” and “Title” text boxes as shown in Figure 49. Click OK.

Figure 50. Saving the scenario

18. Now ALT-TAB to return to the Windows desktop. Open the folder "My Documents/VBS2/mpmissions" and ensure that the "baseline" scenario folder has been created. It will be a folder named "baseline.map_samawah50km_ieed." See Figure 51.

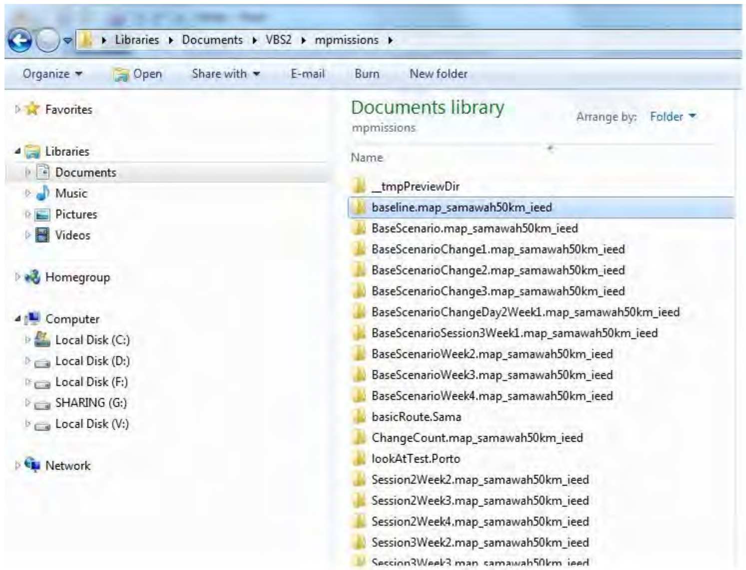

Figure 51. Scenario folder location

19. Open the “baseline.map_samawah50km_ieed” folder. There is no init.sqf or description.ext present in the folder.

20. Using the Windows Start menu, open the basic windows Notepad application. Click File --> Save As. Navigate to the “baseline.map_samawah50km_ieed” folder. Select “All Files” from the “Save as type” dropdown and type init.sqf in the “File Name” text box (See Figure 52).

21. Use the same procedure in (20) to create the description.ext file in the scenario folder.

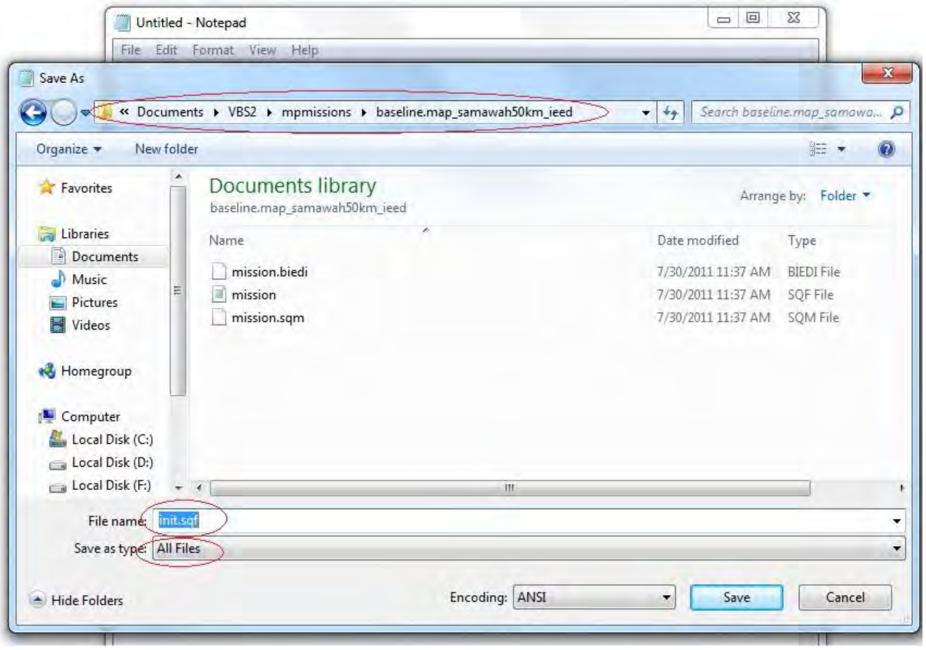

Figure 52. Creating the init.sqf file

22. In the scenario folder, create a new blank folder and name it "SOUND."

23. When complete, the scenario folder contents should look like Figure 53.

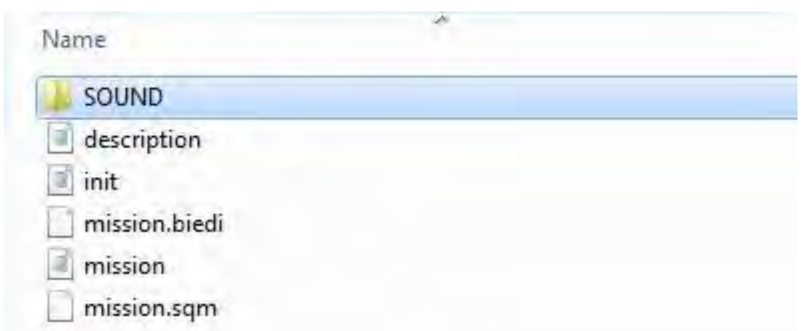

Figure 53. Complete scenario folder

24. Scripts will be written to these blank files later. For now, return to VBS2.

25. To test the vehicle waypoints, run the simulation by clicking File --> Preview. The vehicle will stop at each waypoint. Press 1 then 9 on the keyboard to tell the AI driver to proceed to the next waypoint. After verifying that the vehicle navigates correctly, press the ESC key, then click Abort to return to the editor. If there are issues with vehicle navigation, use the editor to click on the waypoint and drag to adjust to a new location. Keep running the simulation until navigation occurs without any glitches.

26. The next step is to create all ambient vehicle traffic. Vehicle traffic will be created to run in loops around circuits around the scenario area. Ambient vehicle traffic should not share the same road as the participant vehicle unless it is at least a four lane road. On two-lane roads and smaller, ambient vehicle traffic can cause the participant's vehicle to make bad routing decisions. First, create a vehicle at the intersection by selecting the "Vehicle" tab (NOT the "Empty Vehicle") in the lower right of the screen (If this is not visible, click the two-way arrow in the lower right of the screen to expand the panel). For this example, we will choose a city bus. Expand the IQ Civilian Vehicle listing and select the bus as seen in figure 54. This does not need a specific variable name assigned. Click OK.

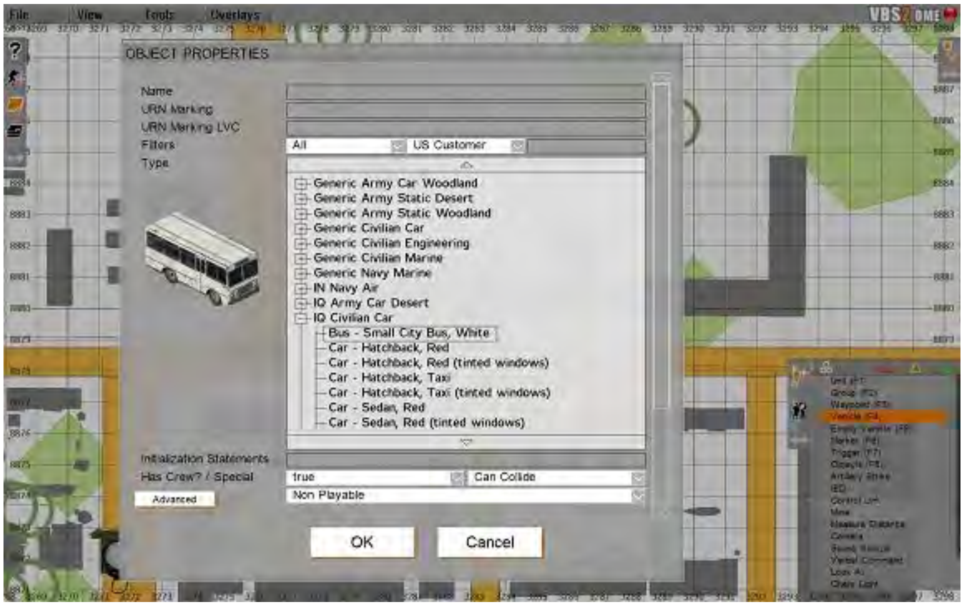

Figure 54. Selecting the Bus for ambient traffic

27. To create a loop, assign a series of waypoints using the RMB pop-up menu and selecting “Add New Waypoint.” Add a series of waypoints in this manner ensuring the last waypoint is near the vehicle’s starting position. To cause the looping behavior, use the RMB menu on the final waypoint, select “Assign Next Waypoint,” and then LMB click on the first waypoint assigned. Each vehicle added requires another run of the simulation for testing. Testing often prevents unknown problems from creeping in.

28. For this scenario, three aircraft were added to the simulation for ambient activity. Create a Blackhawk helicopter at about 319 881. Enter the parameters shown in Figure 11: “hel_1” for “Name,” “hel_1 flyInHeight 150;” in “Initialization Statements,” and “Flying” in the “Special” text box. Click OK.

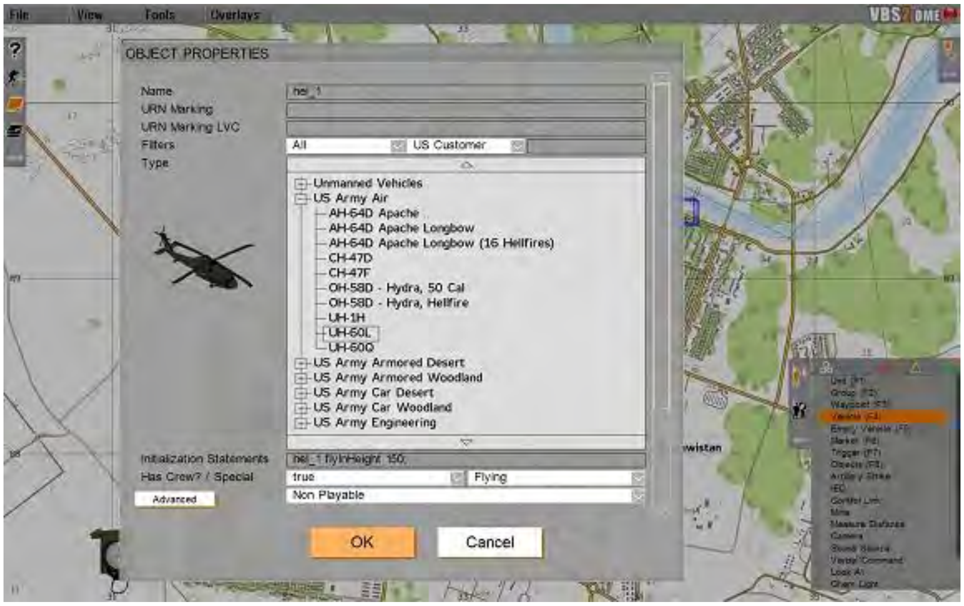

Figure 55. Creating the Blackhawk

29. Click the RMB on the created aircraft and select “Add New Waypoint” and position the waypoint somewhere near the aircraft. Select “Speed Mode” as “Normal” and “Aircraft Height” as “300” and “AGL” as seen in Figure 56. Click OK. Add two additional waypoints so that the helicopter will approach near the participant during the scenario. In the experiment scenario, the helicopter crosses as the participant’s vehicle approaches the first turn (about the 4 minute mark) and about 3 minutes later while traveling down the long Route Red. Since this requires some synchronization, a trigger must be placed to tell the aircraft to proceed to the second waypoint. Create the trigger synchronization as follows:

a. Select “Trigger” in the quick menu at the lower right side of the editor. Double-click the LMB which will bring up the trigger dialogue box. Enter the parameters as seen in Figure 56. Click OK. This will create a rectangular area which will trigger a switch when any friendly unit passes into the area. It has a dimension of 8 x 8 meters in the simulation. It is named helo_trigger.

b. This created trigger will be used to tell the helicopter to proceed to the next waypoint. So, select the first waypoint near the aircraft, click the

RMB, and in the menu choose “Sync to Trigger.” Click on the newly created trigger.

c. Run the simulation and adjust as needed to display proper behavior to the participant.

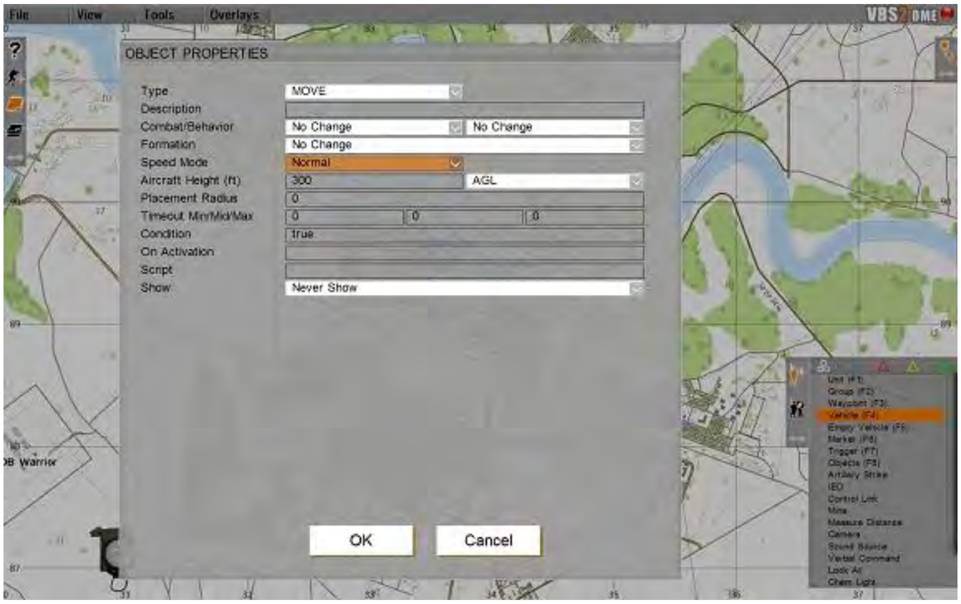

Figure 56. Assigning Blackhawk Waypoint 1

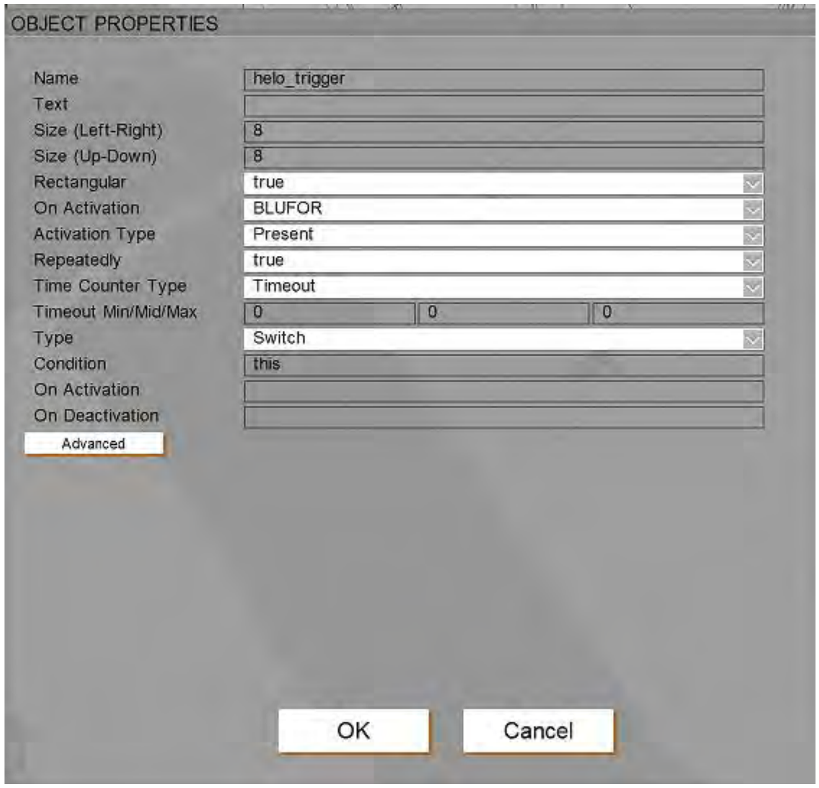

Figure 57. Creating a synchronization trigger

30. Using the same method, create the flight of two AH-64 helicopters so that they pass the participant when they reach the "Victory Bridge" landmark. Continue to run tests for synchronization.

31. Create several sound triggers throughout the route. Using the same idea as the synchronization triggers for aircraft, the sound triggers will be configured to play a specific sound when the participant enters the trigger area. To create a sound trigger in the editor, press F7 or select "Trigger" in the quick menu at the lower right side of the editor. Double-click on the map to place the trigger at the desired location. Fill out the dialog box to match Figure 57. This will create a trigger that will play the prayer call ambient sounds when any friendly unit enters the 10 x 10 area.

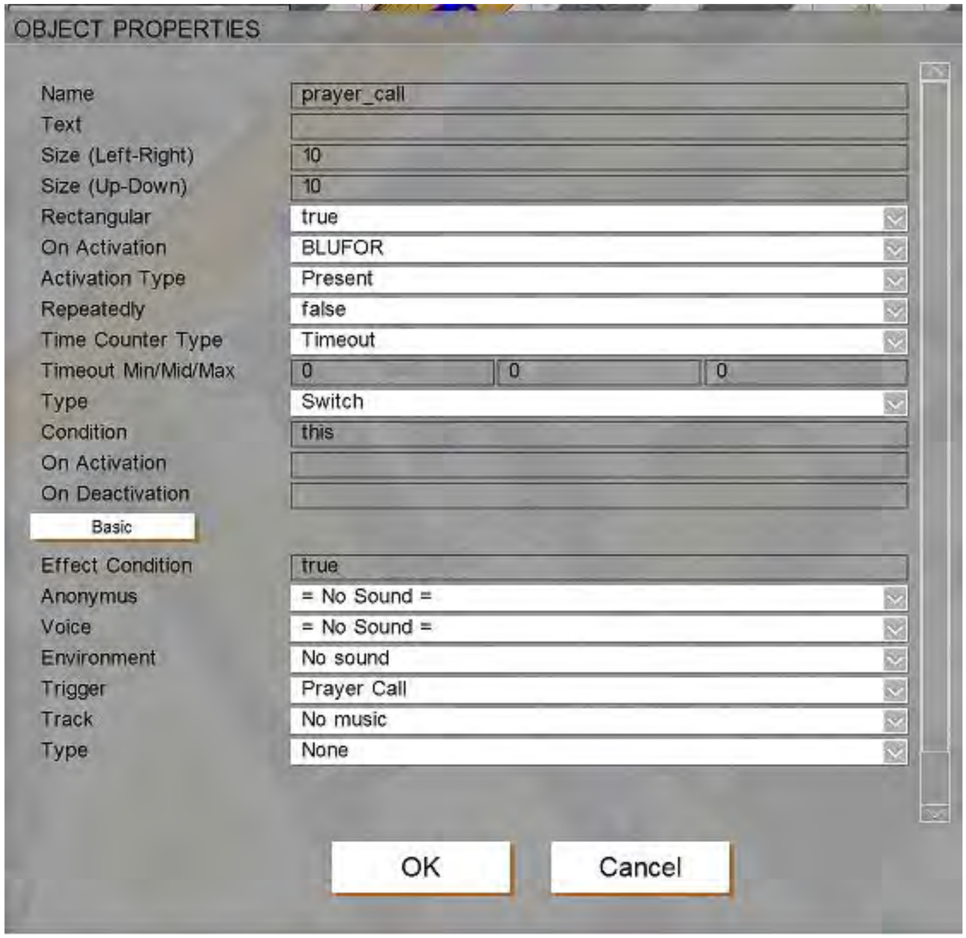

Figure 58. Dialog box for a Prayer Call

32. Run tests to ensure the sounds trigger as desired. Remember, any friendly unit can trigger these triggers, so pay attention to movement of all friendly units, including Iraqi police or soldiers, that it does not accidentally trigger a sound.

33. There are several different ways that the research team introduced people into the scenario. Some are just static placements; they never move. Others have pre-defined looping routes. Some have routes with triggered starts while still others start moving when the scenario begins.

34. To create a group of children that continue running back and forth, create five children at approximately grid 3352 8907. Press F1 or select "Unit"

form the quick menu in the lower right corner of the editor. Double-click on the map to select the position of the child. Expand the "IQ Civilians" list and select one of the children available. Add about five children in this manner.

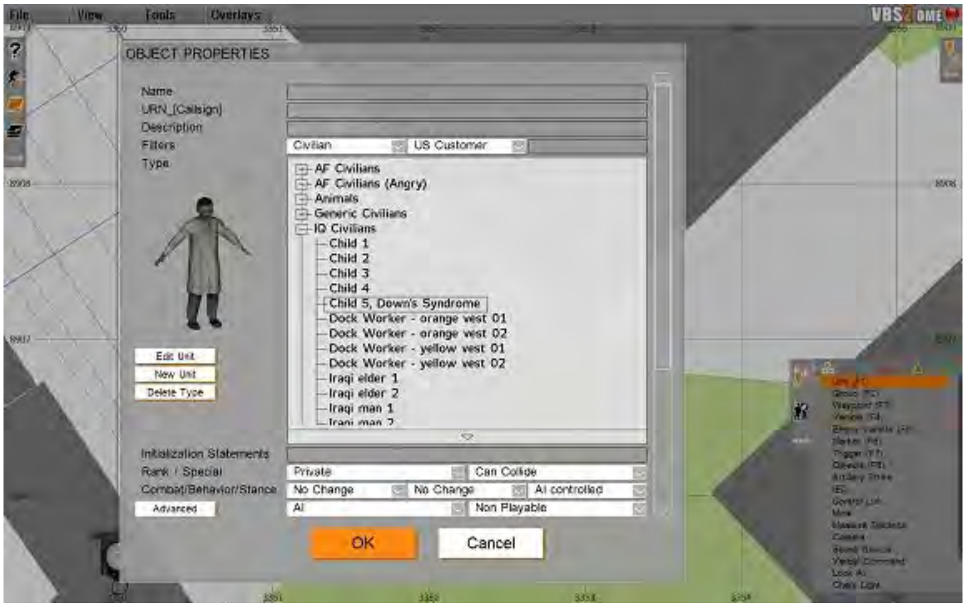

Figure 59. Selecting a child

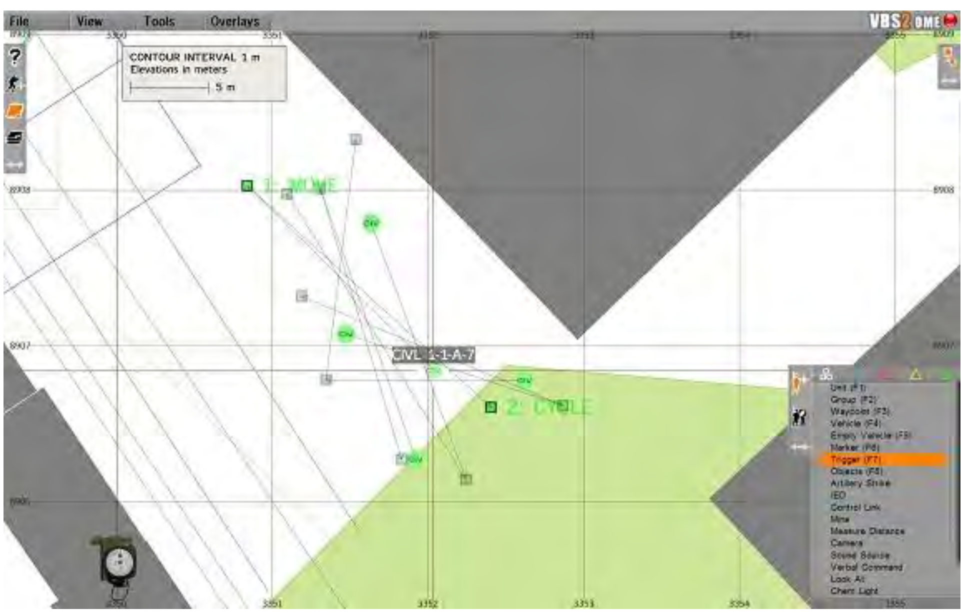

Figure 60. Waypoint map of children playing

35. To cause the children to appear to be playing, create several waypoint cycles. For each child create a set of two waypoints. The first waypoint should be of type “MOVE.” The second waypoint should be of type “CYCLE.” This will cause a looping behavior that will resemble playing.

36. To create a person who will move only when the participant reaches a certain part of the map, a trigger and a waypoint synced to that trigger will again need to be created.

37. To create a small group of men quickly, select from the Group in the quick menu or press F2.

38. To create a person who moves when the simulation begins, simply add a series of waypoints. The person will automatically proceed to the first waypoint when the simulation begins.

39. Static people are added just like objects.

40. When adding any person in VBS2, they will appear to be holding a weapon. However, unless they are police or Army, they will not appear to hold a weapon once the simulation begins.

41. It is critical that as people are added that the simulation is tested each time for possible problems introduced by the new units in the scenario.

42. Next, place objects in the baseline scenario which we can change or manipulate for the change scenarios.

43. For any voiceovers in the simulation, record .wav files. The best freeware program to do this is called Audacity. Audacity is available at http://audacity.sourceforge.net/.

44. To use Audacity to create a .wav file, follow the following steps:

a. Step 1

b. Step 2

45. In order to use the sounds in VBS2, they must be configured to work with the scenario using the *description.ext* file. Before this is written, ensure that all created .wav files to be used in the scenario are moved to the *SOUND* folder in the scenario folder. The format for writing the description.ext is as follows:

```
class CfgSounds
{
 sounds[] = {};
  class soundName1
          {
         name = " soundName 1";
         sound[] = {" soundName1.wav,"1,1};
         titles[] = {};
          };
 class soundName2
          {
         name = " soundName 2";
         sound[] = {" soundName2.wav,"1,1};
         titles[] = {};
          };
};
```

Although it is not required to use the same name in the sound definitions, consistency is recommended. Once this description.ext is created, the following VBS2 scripting command would play the wave file soundName1 in the simulation:

```
playSound "soundName1";
```

46. The init.sqf for the baseline scenario is fairly simple.

```
_blank = "";                        //create a blank string for writing to file
_filename2 = "headDirection.txt";  //create a variable for the filename

_append = format["Write(%1)@%2,"_filename2,_blank];  //format the file to be written
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append]; //write the file to the specified text file
hint "This is a test."; //display the dialog "This is a test" on the screen for the
```

```
pareticipant
playSound "test";  //play the voiceover wav file associated with "test" in description.ext
sleep 5;         //pause 5 seconds before executing the next line.  This should be at least as long as the                //previous .wav file to avoid crossover.
hint "This is test2"; //display the dialog "This is a test2" on the screen for the pareticipant
playSound "test2";//play the voiceover wav file associated with "test2" in description.ext
sleep 5;         //pause 5 seconds before executing the next line.  This should be at least as long as the previous //.wav file to avoid crossover
while {alive player} do //begin execution of a do while loop that continues while the player is still alive.
                        //it will write the relative head direction of the participant every 0.2 seconds (adjust sleep
                      //parameter to change)on a new line in the file headDirection.txt including current sim time
        {
        _headDir = getDir player;
        _vehDir = getDir veh_1;
        _relDir = _headDir - _vehDir;
        _time = time;
        _append = format["AppendLine(%1)@%2,%3,"_filename2,_relDir,_time];
        _writeFile = pluginFunction ["VBSPluginFileAccess" , _append];
        sleep 0.2;
        };
```

47. When all objects and triggers have been placed in the base scenario, test it several times to ensure consistency in performance. If any anomalous behavior presents itself, work back from the last change and run again. Sometimes adjusting the waypoint of the HMMWV route slightly will rectify the issue.

48. Save the baseline scenario.

49. With the baseline scenario open in the 2-D editor, save the scenario again as "Change_1." This provides the baseline as a model for creating the first change scenario.

50. Now remove and place objects as necessary to create the first scenario. It is important to name objects that will be identified as a change

because that variable name will be added to the array which lists all the changes in the scenario.

51. Create three blank external.sqf files. Using the Windows Start menu, open the basic windows Notepad application. Click File --> Save As. Navigate to the “baseline.map_samawah50km_ieed” folder. Select “All Files” from the “Save as type” dropdown and type low.sqf in the “File Name” text box (See Figure 8). Using the same method, create two additional .sqf files named med.sqf and high.sqf.

52. Bind keys in init.sqf. Open the init.sqf file and write the following lines of code to bind key presses to the external .sqf files just created. Using the [DIK code reference](), determine the codes for which keys to bind. The following codes were used in the experiment:

DIK_C 0x2E
DIK_V 0x2F
DIK_B 0x30
The script to bind the key to execution of the appropriate external script file is as follows:
0x2E bindKey “nul = [] execVM ‘low.sqf’”; //binds the “C” key to execution of low.sqf.
0x2F bindKey “nul = [] execVM ‘med.sqf’”; //binds the “V” key to execution of med.sqf.
0x30 bindKey “nul = [] execVM ‘high.sqf’”; //binds the “B” key to execution of high.sqf.

53. In init.sqf, instantiate the array of objects to be identified as changes in the scenario. Use the variable names set when creating the object in the editor. An example array for three changes in a scenario would be instantiated in init.sqf as follows:

changeArray = [change1, change 2, change3];

54. Now write the external script files. Start with low.sqf and then take advantage of copy and paste to write med.sqf and high.sqf. The code for a script

file which looks for an changes listed in the changeArray for a distance of 60 meters and within a 15 degree azimuth follows:

```
totalClicks = totalClicks + 1;  //add to tally of total presses
clickL = clickL + 1;  //add to tally of low confidence presses
_1click = "lowConf";  //create a string variable for data output
_blank = "";  //create a string variable for blank lines
_headDir = getDir player;
_vehDir = getDir veh_1;
_relDir = _headDir - _vehDir;  //compute head direction relative to vehicle front at
button press time
_time = time;   //get sim time at time of button press
_filename = "targetsFound.txt";  //name the text file to append
_filename3 = "clicked.txt";  //name another text file to append
_append =
format["AppendLine(%1)@%2,%3,%4,"_filename3,_1click,_relDir,_time]; //record
button //press
_writeFile = pluginFunction ["VBSPluginFileAccess" , _append];  //write to file
{
    if ((player isLookingAt [_x,15]) && ((player distance _x) < 60)) then{   //check
60 meters and 15 degree
    _filename = "targetsFound.txt";  //string variable for data
    _confidence = "conf1correct";  //string variable for data
    scoreL = scoreL + 1;  //add to low confidence correct
    totalCorrect = totalCorrect + 1;  //add to total correct
    _append =
format["AppendLine(%1)@%2,%3,%4,%5,"_filename,_x,_relDir,_time,_1click];
    _writeFile = pluginFunction ["VBSPluginFileAccess" , _append];  //write to file
    playSound "dinger";  //play ding sound for knowledge of results
    };
}forEach changeArray; //check for each item in the changeArray
```

55. Run the scenario. Test low, medium, and high confidence levels. Check data files. All data files will write to the VBS2 root folder located at C:/Bohemia Interactive/VBS2.

56. To create another change scenario, open the baseline scenario and then save under a new name such as "Change2"

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APPENDIX K. CHANGES USED IN THIS EXPERIMENT

A. SCENARIO 1

Figure 61. Map of Changes in Scenario 1

Figure 62. Scenario 1, Change 1 (before): tire_1

Figure 63. Scenario 1, Change 1 (after): tire_1

Figure 64. Scenario 1, Change 2 (before): burnt_truck_1

Figure 65. Scenario 1, Change 2 (after): burnt_truck_1

Figure 66. Scenario 1, Change 3 (before): propane_tank_sales_1

Figure 67. Scenario 1, Change 3 (after): propane_tank_sales_1

Figure 68. Scenario 1, Change 4 (before): broken_wall_1

Figure 69. Scenario 1, Change 4 (after): broken_wall_1

Figure 70. Scenario 1, Change 5 (before): dirt_pile_1

Figure 71. Scenario 1, Change 5 (after): dirt_pile_1

Figure 72. Scenario 1, Change 6 (before): observer_1

Figure 73. Scenario 1, Change 6 (after): observer_1

Figure 74. Scenario 1, Change 7 (before): vid_camera_1

Figure 75. Scenario 1, Change 7 (after): vid_camera_1

Figure 76. Scenario 1, Change 8 (before): running_man_1

Figure 77. Scenario 1, Change 8 (after): running_man_1

Figure 78. Scenario 1, Change 9 (before): ied_box_1

Figure 79. Scenario 1, Change 9 (after): ied_box_1

Figure 80. Scenario 1, Change 10 (before): ied_supply_man_1

Figure 81. Scenario 1, Change 10 (after): ied_supply_man_1

Figure 82. Scenario 1, Change 11 (before): odd_drums_1

Figure 83. Scenario 1, Change 11 (after): odd_drums_1

Figure 84. Scenario 1, Change 12 (before): vbied_van_1

Figure 85. Scenario 1, Change 12 (after): vbied_van_1

Figure 86. Scenario 1, Change 13 (before): ied_patch_1

Figure 87. Scenario 1, Change 13 (after): ied_patch_1

Figure 88. Scenario 1, Change 14 (before): burkha_girl_1

Figure 89. Scenario 1, Change 14 (after): burkha_girl_1

Figure 90. Scenario 1, Change 15 (before): ruined_house_1

Figure 91. Scenario 1, Change 15 (after): ruined_house_1

Figure 92. Scenario 1, Change 16 (before): broken_wall_2

Figure 93. Scenario 1, Change 16 (after): broken_wall_2

Figure 94. Scenario 1, Change 17 (before): bad_trash_pile_1

Figure 95. Scenario 1, Change 17 (after): bad_trash_pile_1

Figure 96. Scenario 1, Change 18 (before): broken_wall_ied_1

Figure 97. Scenario 1, Change 18 (after): broken_wall_ied_1

Figure 98. Scenario 1, Change 19 (before): broken_guardrail_1

Figure 99. Scenario 1, Change 19 (after): broken_guardrail_1

Figure 100. Scenario 1, Change 20 (before): bad_curb_1

Figure 101. Scenario 1, Change 20 (after): bad_curb_1

Figure 102. Scenario 1, Change 21 (before): reporter_1

Figure 103. Scenario 1, Change 21 (after): reporter_1

Figure 104. Scenario 1, Change 22 (before): bad_bag_pile_1

Figure 105. Scenario 1, Change 22 (after): bad_bag_pile_1

Figure 106. Scenario 1, Change 23 (before): bad_barrels_1

Figure 107. Scenario 1, Change 23 (after): bad_barrels_1

Figure 108. Scenario 1, Change 24 (before): bad_rubble_1

Figure 109. Scenario 1, Change 24 (after): bad_rubble_1

Figure 110. Scenario 1, Change 25 (before): broken_fence_no_ip_1

Figure 111. Scenario 1, Change 25 (after): broken_fence_no_ip_1

Figure 112. Scenario 1, Change 26 (before): buried_tank_1

Figure 113. Scenario 1, Change 26 (after): buried_tank_1

Figure 114. Scenario 1, Change 27 (before): new_containers_1

Figure 115. Scenario 1, Change 27 (after): new_containers_1

Figure 116. Scenario 1, Change 28 (before): poster_wall_1

Figure 117. Scenario 1, Change 28 (after): poster_wall_1

Figure 118. Scenario 1, Change 29 (before): concrete_ied_1

Figure 119. Scenario 1, Change 29 (after): concrete_ied_1

Figure 120. Scenario 1, Change 30 (before): bad_mixer_1

Figure 121. Scenario 1, Change 30 (after): bad_mixer_1

B. SCENARIO 2

Figure 122. Scenario 2, Change 1 (before): truck_wreck

Figure 123. Scenario 2, Change 1 (after): truck_wreck

Figure 124. Scenario 2, Change 2 (before): fridge_no_play

Figure 125. Scenario 2, Change 2 (after): fridge_no_play

Figure 126. Scenario 2, Change 3 (before): suicide_bomber

Figure 127. Scenario 2, Change 3 (after): suicide_bomber

Figure 128. Scenario 2, Change 4 (before): dead_body

Figure 129. Scenario 2, Change 4 (after): dead_body

Figure 130. Scenario 2, Change 5 (before): bomb_maker

Figure 131. Scenario 2, Change 5 (after): bomb_maker

Figure 132. Scenario 2, Change 6 (before): new_rock

Figure 133. Scenario 2, Change 6 (after): new_rock

Figure 134. Scenario 2, Change 7 (before): new_van

Figure 135. Scenario 2, Change 7 (after): new_van

Figure 136. Scenario 2, Change 8 (before): boarded_up_shop

Figure 137. Scenario 2, Change 8 (after): boarded_up_shop

Figure 138. Scenario 2, Change 9 (before): weird_dudes

Figure 139. Scenario 2, Change 9 (after): weird_dudes

Figure 140. Scenario 2, Change 10 (before): press_man

Figure 141. Scenario 2, Change 10 (after): press_man

Figure 142. Scenario 2, Change 11 (before): bomb_car

Figure 143. Scenario 2, Change 11 (after): bomb_car

Figure 144. Scenario 2, Change 12 (before): back_to_back_vans

Figure 145. Scenario 2, Change 12 (after): back_to_back_vans

Figure 146. Scenario 2, Change 13 (before): UN_sacks

Figure 147. Scenario 2, Change 13 (after): UN_sacks

Figure 148. Scenario 2, Change 14 (before): ice_cream_dude

Figure 149. Scenario 2, Change 14 (after): ice_cream_dude

Figure 150. Scenario 2, Change 15 (before): bad_pile

Figure 151. Scenario 2, Change 15 (after): bad_pile

Figure 152. Scenario 2, Change 16 (before): new_boxes_no_phone_booth

Figure 153. Scenario 2, Change 16 (after): new_boxes_no_phone_booth

Figure 154. Scenario 2, Change 17 (before): new_tractor

Figure 155. Scenario 2, Change 17 (after): new_tractor

Figure 156. Scenario 2, Change 18 (before): nobody_ia_cp

Figure 157. Scenario 2, Change 18 (after): nobody_ia_cp

Figure 158. Scenario 2, Change 19 (before): new_car_open_street

Figure 159. Scenario 2, Change 19 (after): new_car_open_street

Figure 160. Scenario 2, Change 20 (before): broken_wall

Figure 161. Scenario 2, Change 20 (after): broken_wall

Figure 162. Scenario 2, Change 21 (before): turned_truck

Figure 163. Scenario 2, Change 21 (after): turned_truck

Figure 164. Scenario 2, Change 22 (before): jingle_truck

Figure 165. Scenario 2, Change 22 (after): jingle_truck

Figure 166. Scenario 2, Change 23 (before): new_rubble_no_kids

Figure 167. Scenario 2, Change 23 (after): new_rubble_no_kids

Figure 168. Scenario 2, Change 24 (before): wall_truck

Figure 169. Scenario 2, Change 24 (after): wall_truck

Figure 170. Scenario 2, Change 25 (before): ip_suicide_bomber

Figure 171. Scenario 2, Change 25 (after): ip_suicide_bomber

Figure 172. Scenario 2, Change 26 (before): propane_tanks

Figure 173. Scenario 2, Change 26 (after): propane_tanks

Figure 174. Scenario 2, Change 27 (before): bad_cart

Figure 175. Scenario 2, Change 27 (after): bad_cart

Figure 176. Scenario 2, Change 28 (before): new_cars

Figure 177. Scenario 2, Change 28 (after): new_cars

Figure 178. Scenario 2, Change 29 (before): van_bomb

Figure 179. Scenario 2, Change 29 (after): van_bomb

Figure 180. Scenario 2, Change 30 (before): new_barrels

Figure 181. Scenario 2, Change 30 (after): new_barrels

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APPENDIX L. POTENTIAL TARGET (CHANGE) LOCATIONS

A. OVERVIEW MAP

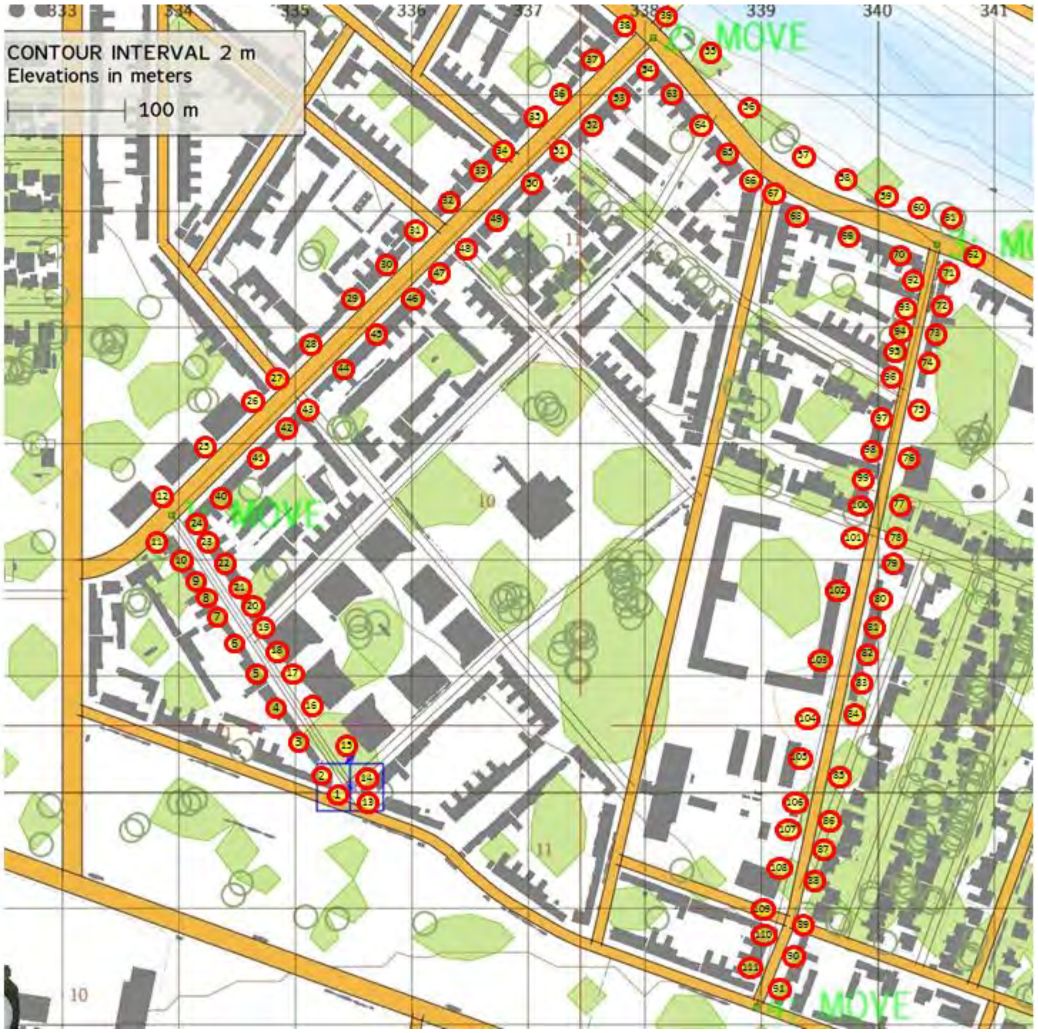

Figure 182. Overview Map of VBS2™ scene locations

B. LOCATIONS FOR POTENTIAL CHANGES IN A SCENE

In the following 112-screen captures, red crosses mark the nearly 5000 locations where a change could potentially occur in the environment. The yellow crosses represent locations already labeled with a red cross in another figure.

Figure 183. Scene 1, left side of vehicle, Route Blue, 19 potential changes

Figure 184. Scene 2, left side of vehicle, Route Blue, 31 potential changes

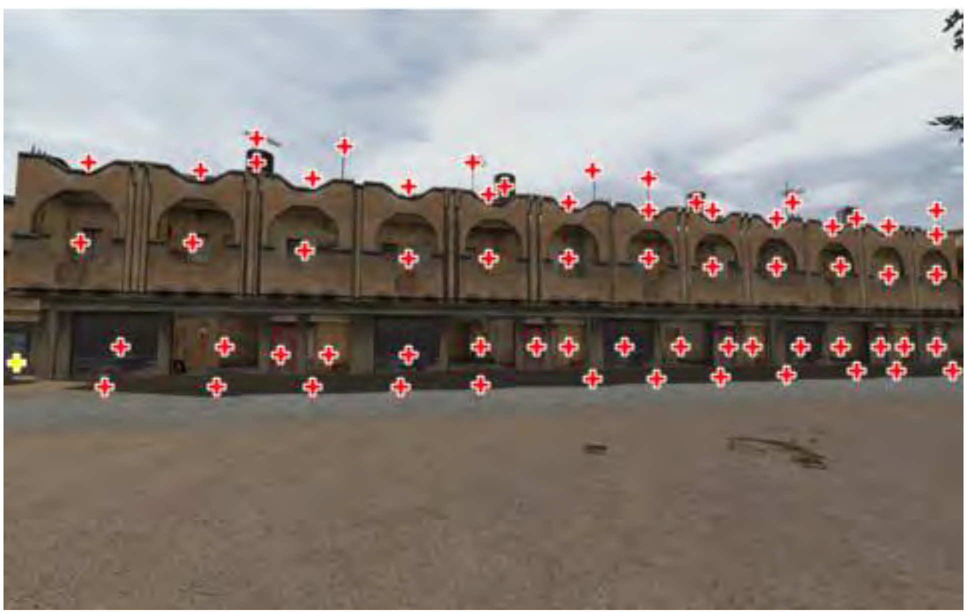

Figure 185. Scene 3, left side of vehicle, Route Blue, 64 potential changes

Figure 186. Scene 4, left side of vehicle, Route Blue, 32 potential changes

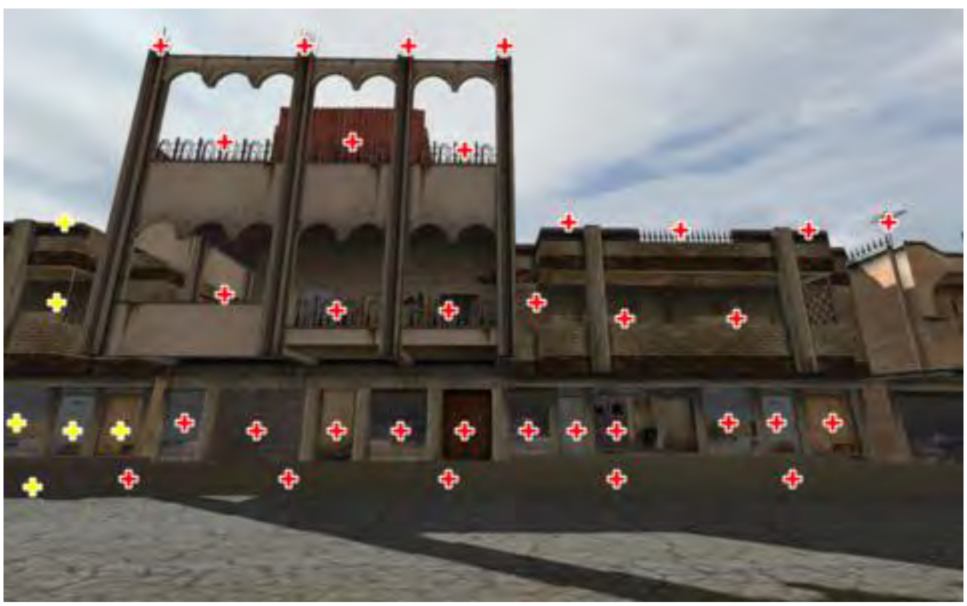

Figure 187. Scene 5, left side of vehicle, Route Blue, 33 potential changes

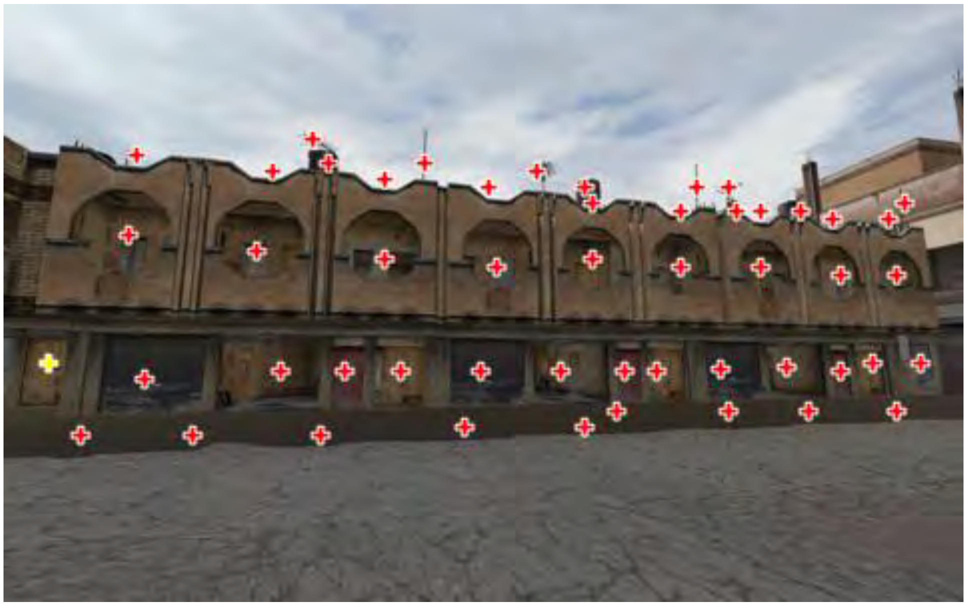

Figure 188. Scene 6, left side of vehicle, Route Blue, 50 potential changes

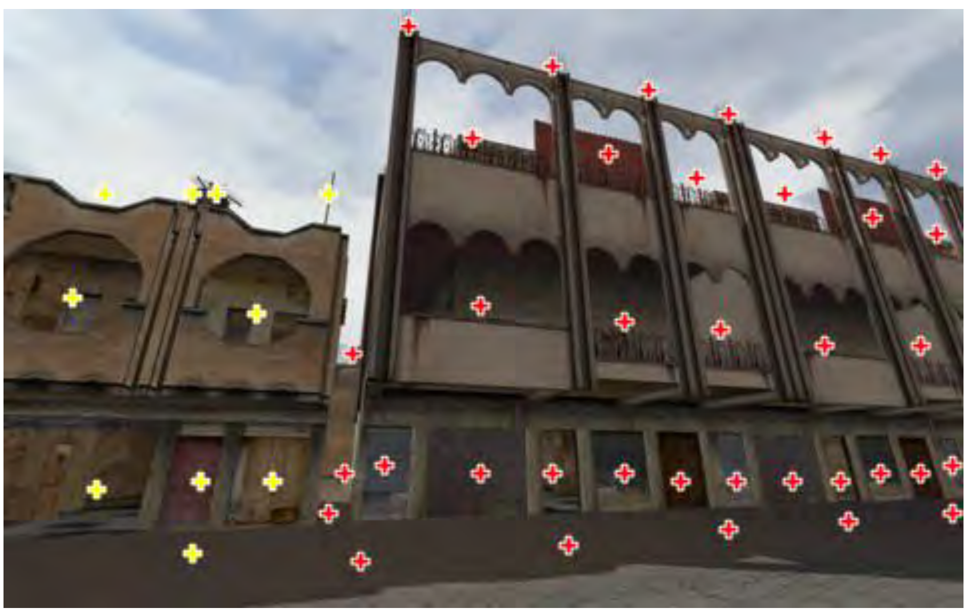

Figure 189. Scene 7, left side of vehicle, Route Blue, 37 potential changes

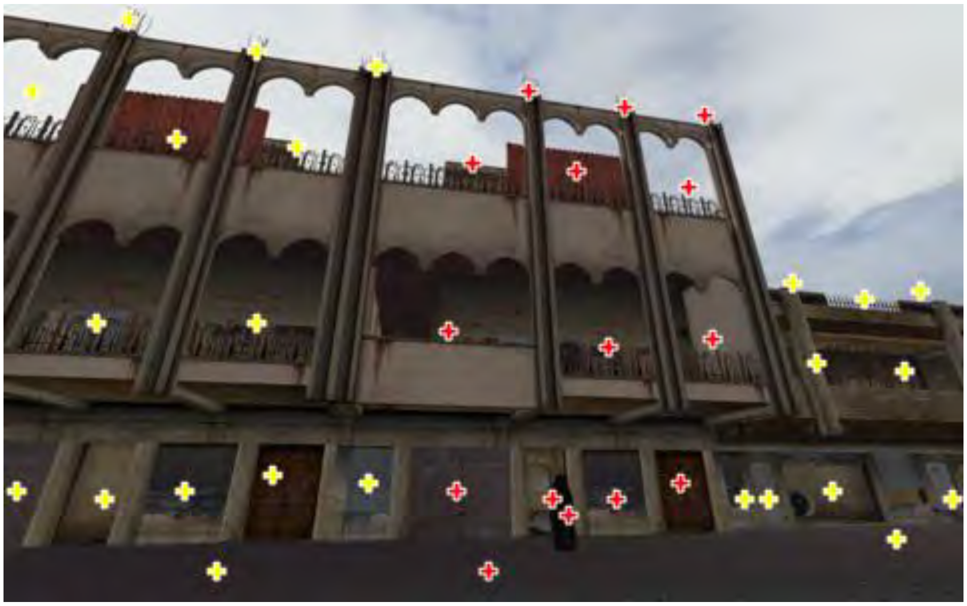

Figure 190. Scene 8, left side of vehicle, Route Blue, 15 potential changes

Figure 191. Scene 9, left side of vehicle, Route Blue, 21 potential changes

Figure 192. Scene 10, left side of vehicle, Route Blue, 31 potential changes

Figure 193. Scene 11, left side of vehicle, Route Blue, 23 potential changes

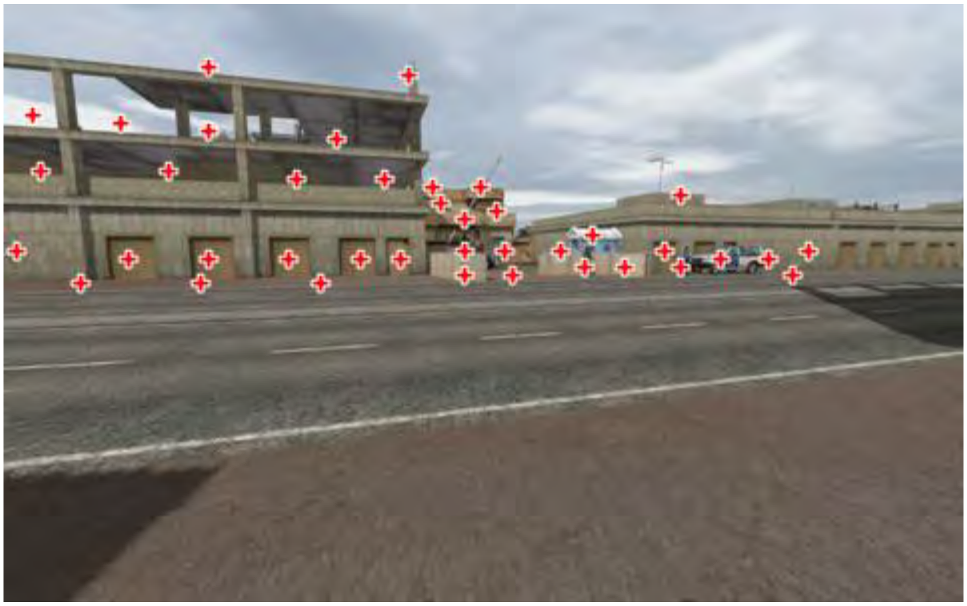

Figure 194. Scene 12, left side of vehicle, Route Red, 39 potential changes

Figure 195. Scene 13, right side of vehicle, Route Blue, 17 potential changes

Figure 196. Scene 14, right side of vehicle, Route Blue, 49 potential changes

Figure 197. Scene 15, right side of vehicle, Route Blue, 49 potential changes

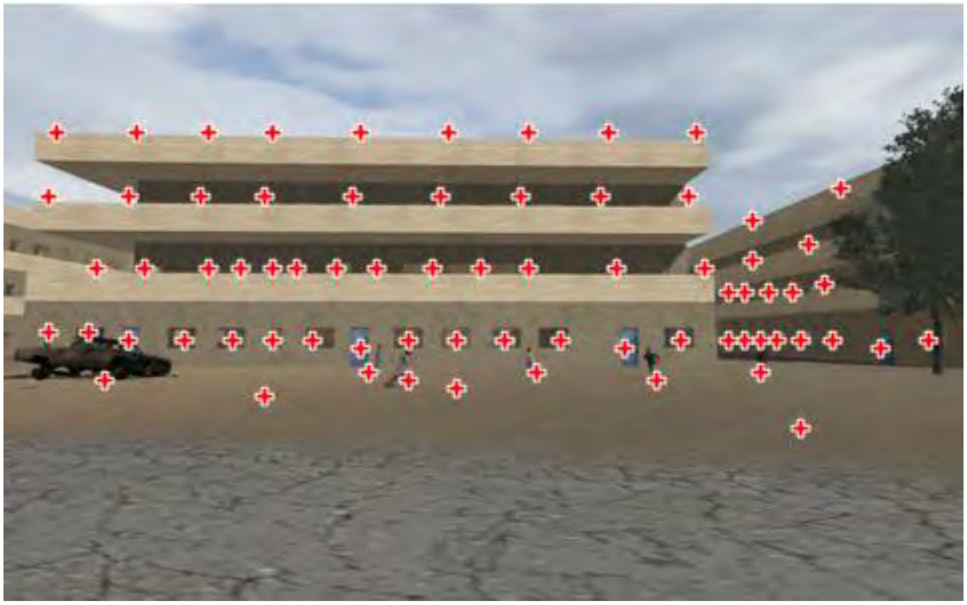

Figure 198. Scene 16, right side of vehicle, Route Blue, 66 potential changes

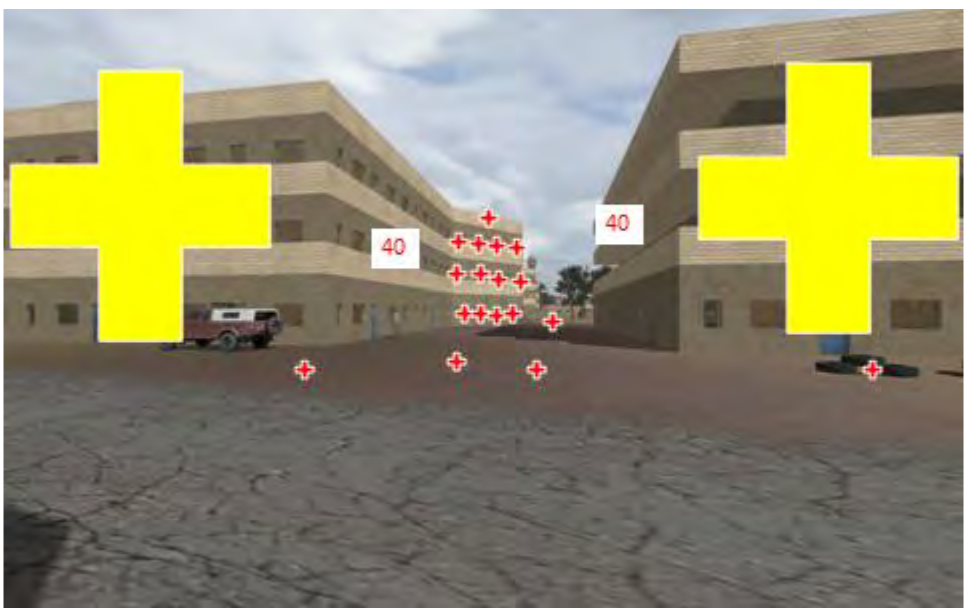

Figure 199. Scene 17, right side of vehicle, Route Blue, 98 potential changes

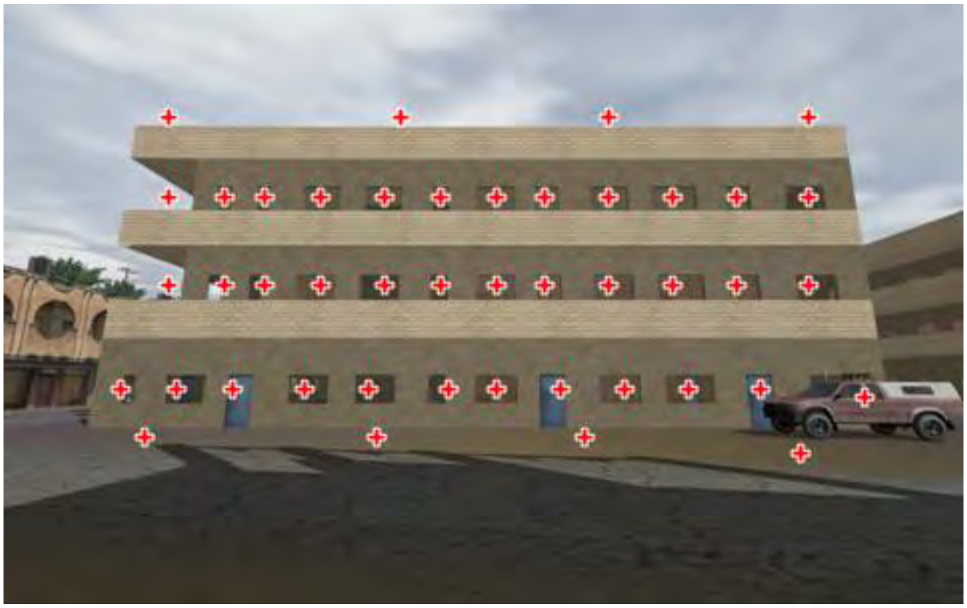

Figure 200. Scene 18, right side of vehicle, Route Blue, 44 potential changes

Figure 201. Scene 19, right side of vehicle, Route Blue, 93 potential changes

Figure 202. Scene 20, right side of vehicle, Route Blue, 29 potential changes

Figure 203. Scene 21, right side of vehicle, Route Blue, 27 potential changes

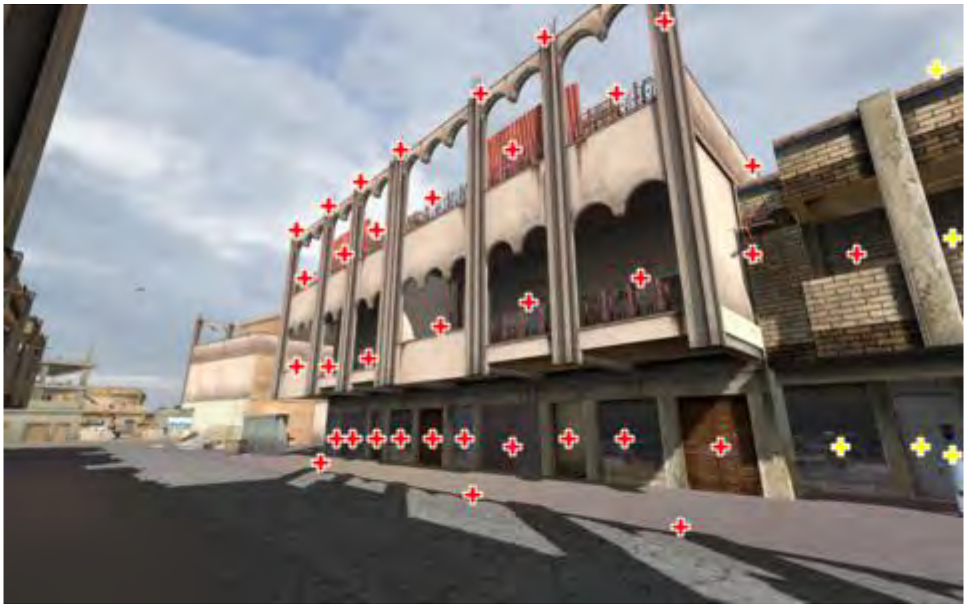

Figure 204. Scene 22, right side of vehicle, Route Blue, 35 potential changes

Figure 205. Scene 23, right of vehicle, Route Blue, 23 potential changes

Figure 206. Scene 24, right of vehicle, Route Blue, 13 potential changes

Figure 207. Scene 25, left of vehicle, Route Red, 31 potential changes

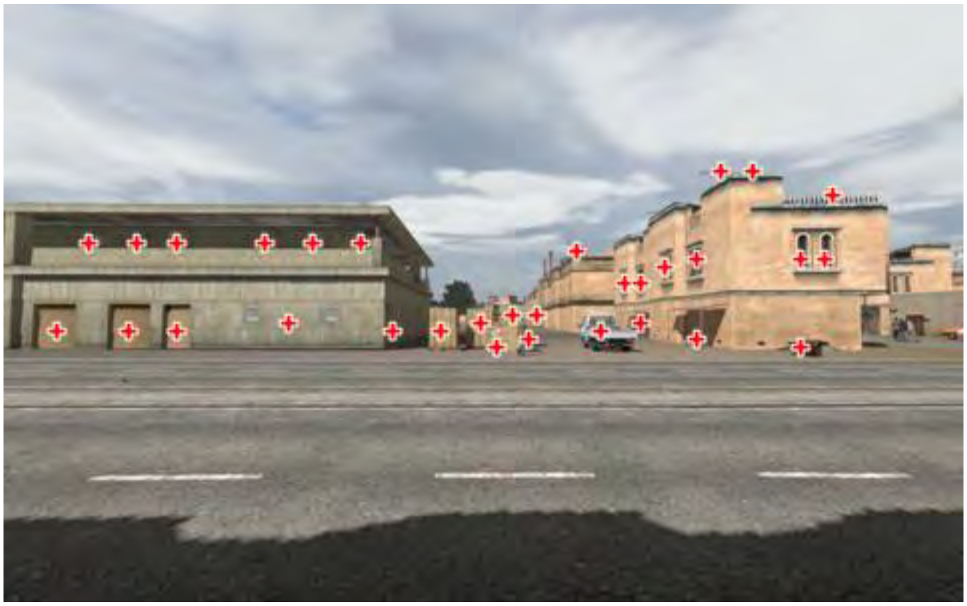

Figure 208. Scene 26, left of vehicle, Route Red, 31 potential changes

Figure 209. Scene 27, left of vehicle, Route Red, 46 potential changes

Figure 210. Scene 28, left of vehicle, Route Red, 61 potential changes

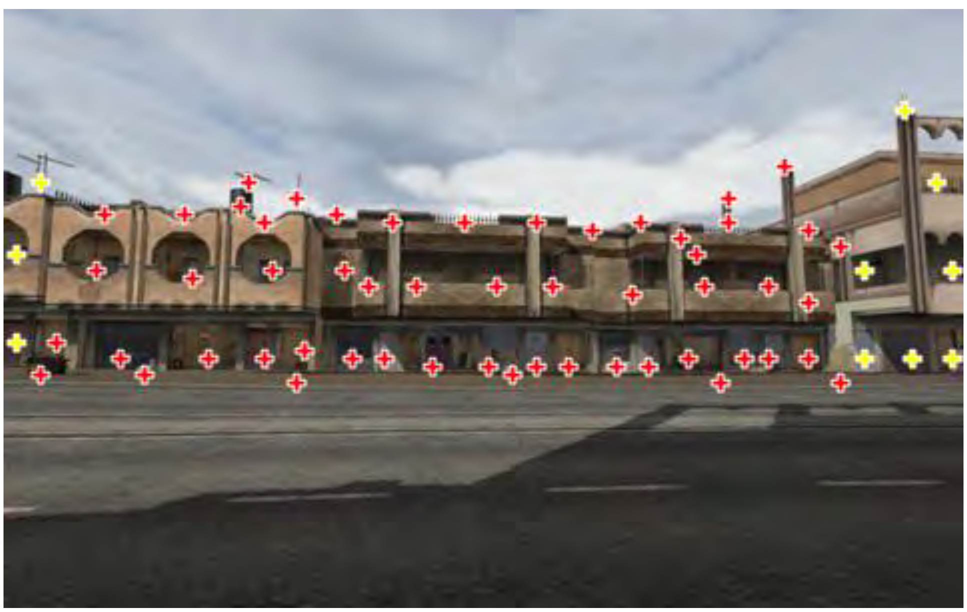

Figure 211. Scene 29, left of vehicle, Route Red, 54 potential changes

Figure 212. Scene 30, left of vehicle, Route Red, 56 potential changes

Figure 213. Scene 31, left side of vehicle, Route Red, 63 potential changes

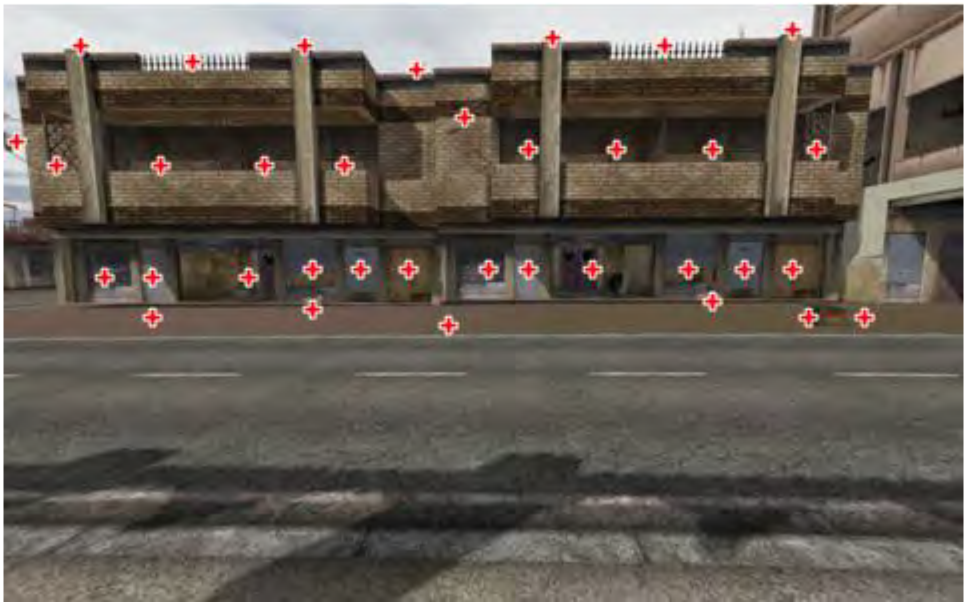

Figure 214. Scene 32, left side of vehicle, Route Red, 35 potential changes

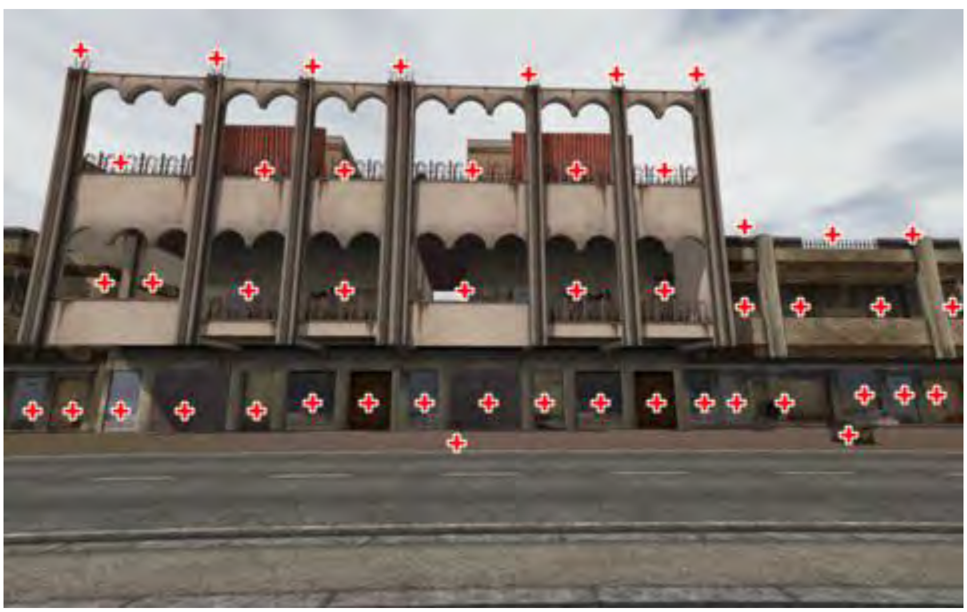

Figure 215. Scene 33, left side of vehicle, Route Red, 50 potential changes

Figure 216. Scene 34, left side of vehicle, Route Red, 36 potential changes

Figure 217. Scene 35, left side of vehicle, Route Red, 37 potential changes

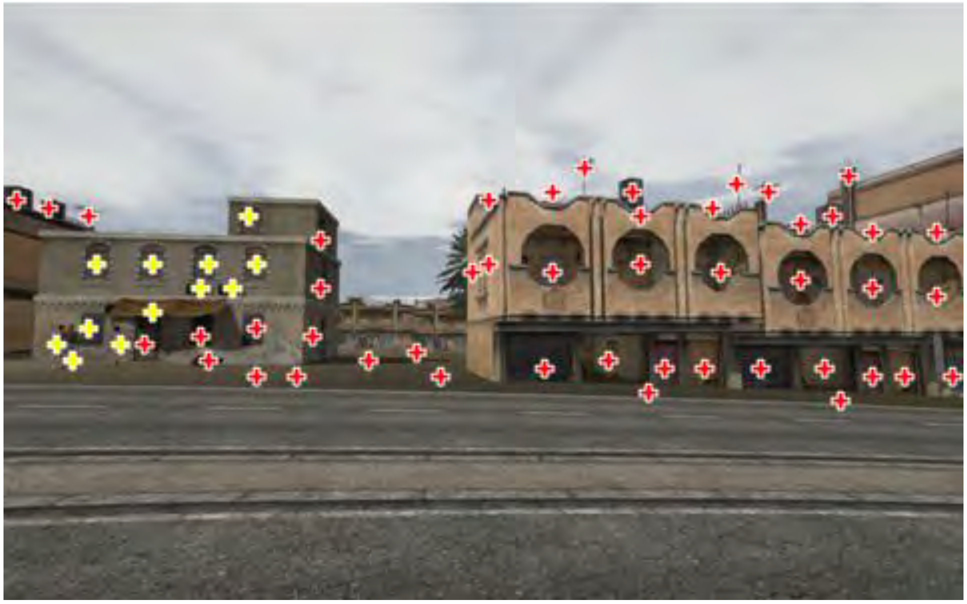

Figure 218. Scene 36, left side of vehicle, Route Red, 47 potential changes

Figure 219. Scene 37, left side of vehicle, Route Red, 53 potential changes

Figure 220. Scene 38, left side of vehicle, Route Red, 14 potential changes

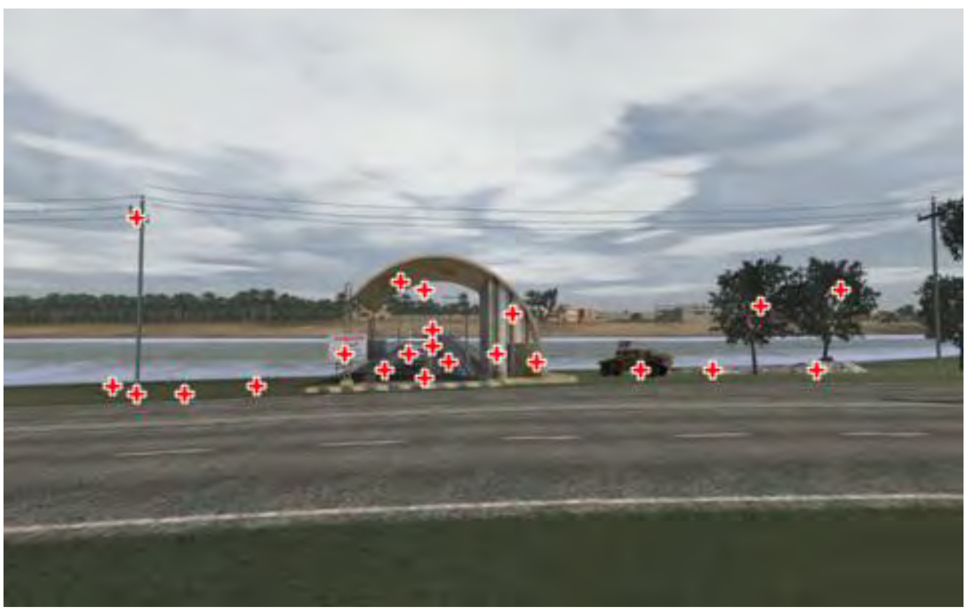

Figure 221. Scene 39, left side of vehicle, Route Green, 22 potential changes

Figure 222. Scene 40, right side of vehicle, Route Red, 46 potential changes

Figure 223. Scene 41, right side of vehicle, Route Red, 58 potential changes

Figure 224. Scene 42, right side of vehicle, Route Red, 55 potential changes

Figure 225. Scene 43, right of vehicle, Route Red, 29 potential changes

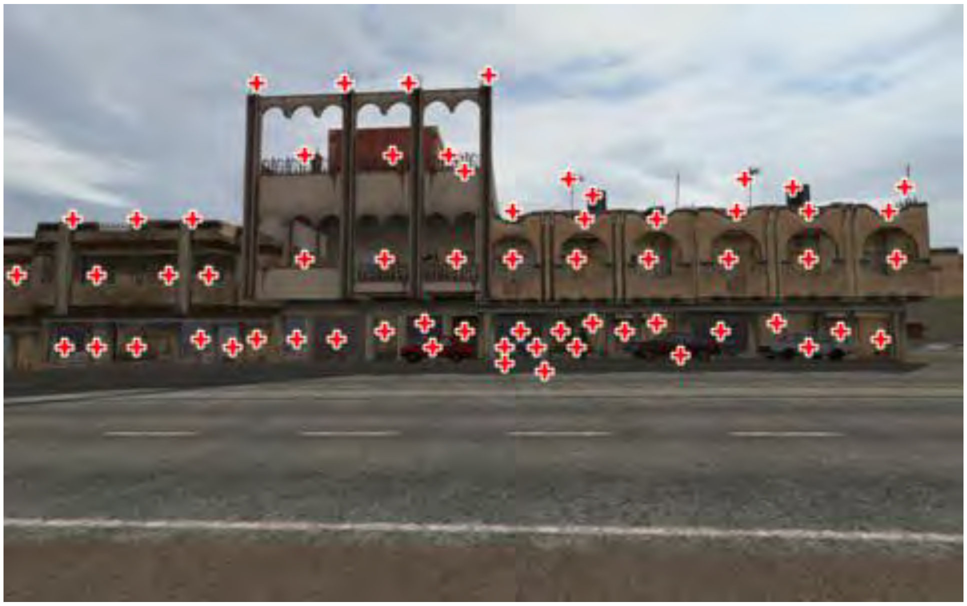

Figure 226. Scene 44, right of vehicle, Route Red, 63 potential changes

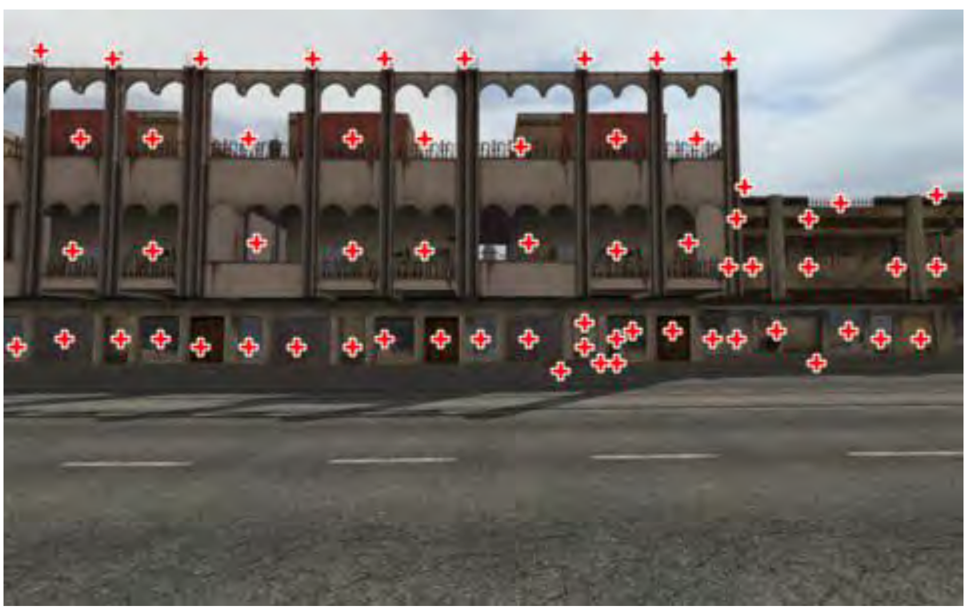

Figure 227. Scene 45, right side of vehicle, Route Red, 62 potential changes

Figure 228. Scene 46, right side of vehicle, Route Red, 35 potential changes

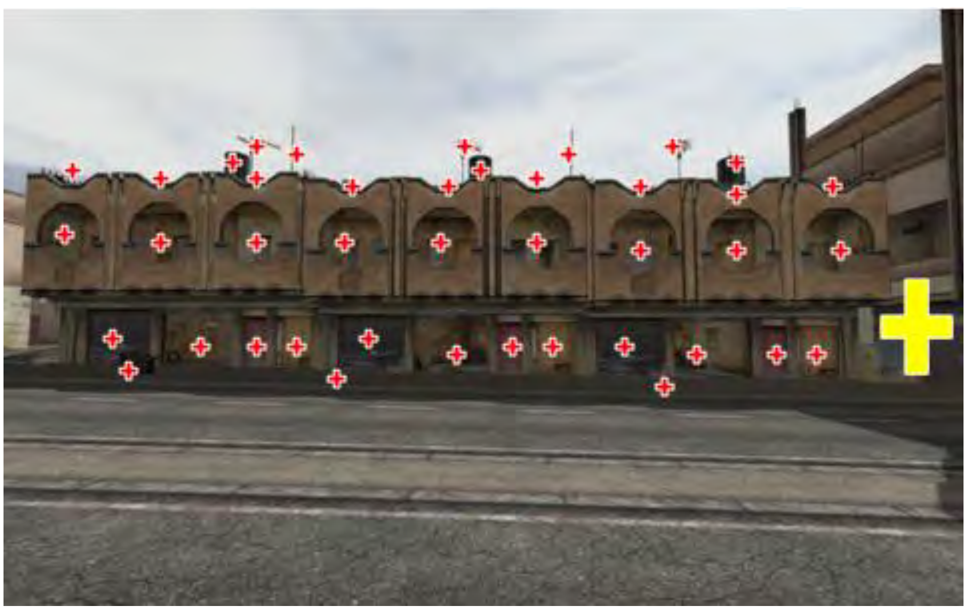

Figure 229. Scene 47, right side of vehicle, Route Red, 41 potential changes

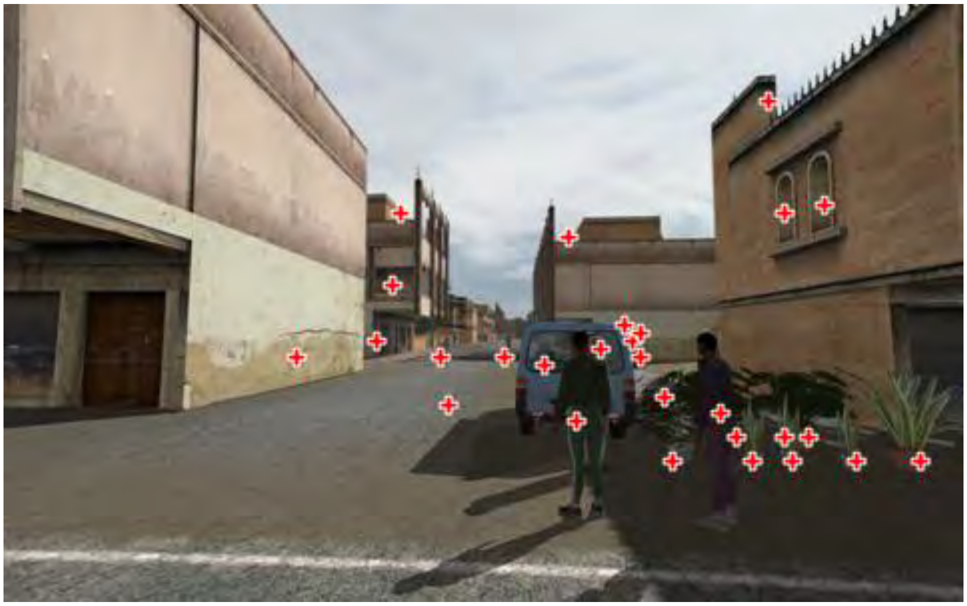

Figure 230. Scene 48, right side of vehicle, Route Red, 28 potential changes

Figure 231. Scene 49, right side of vehicle, Route Red, 46 potential changes

Figure 232. Scene 50, right side of vehicle, Route Red, 52 potential changes

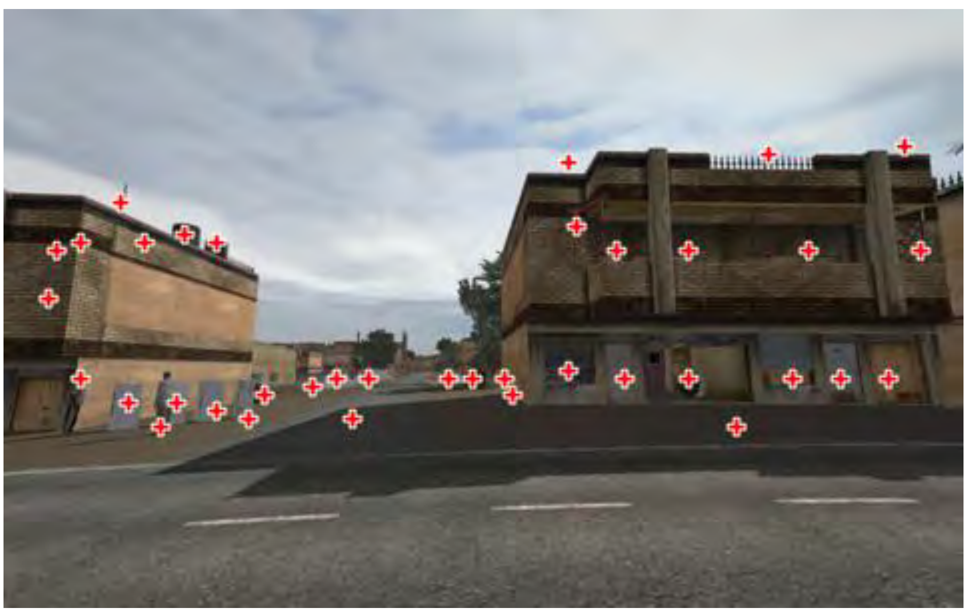

Figure 233. Scene 51, right side of vehicle, Route Red, 37 potential changes

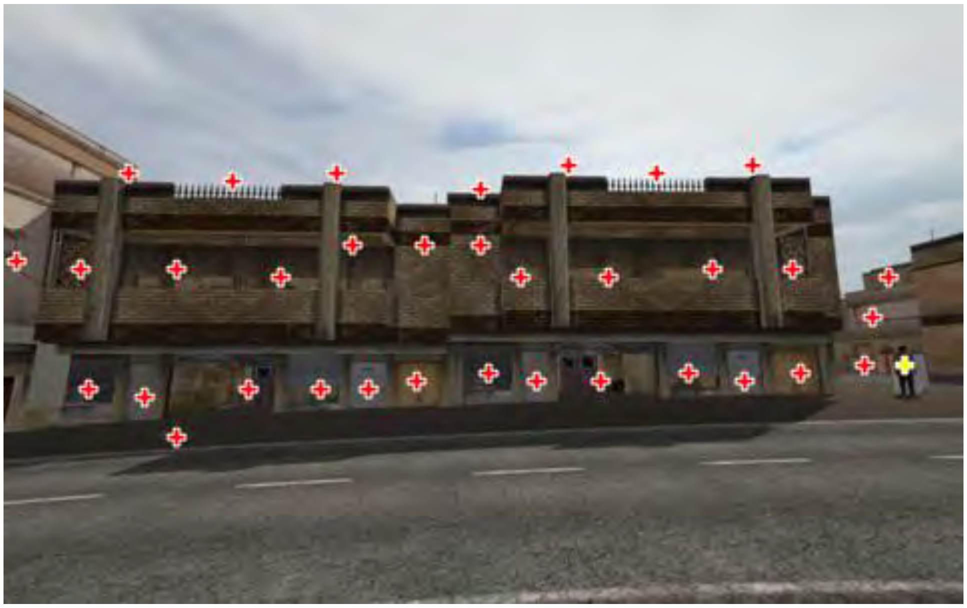

Figure 234. Scene 52, right side of vehicle, Route Red, 36 potential changes

Figure 235. Scene 53, right side of vehicle, Route Red, 52 potential changes

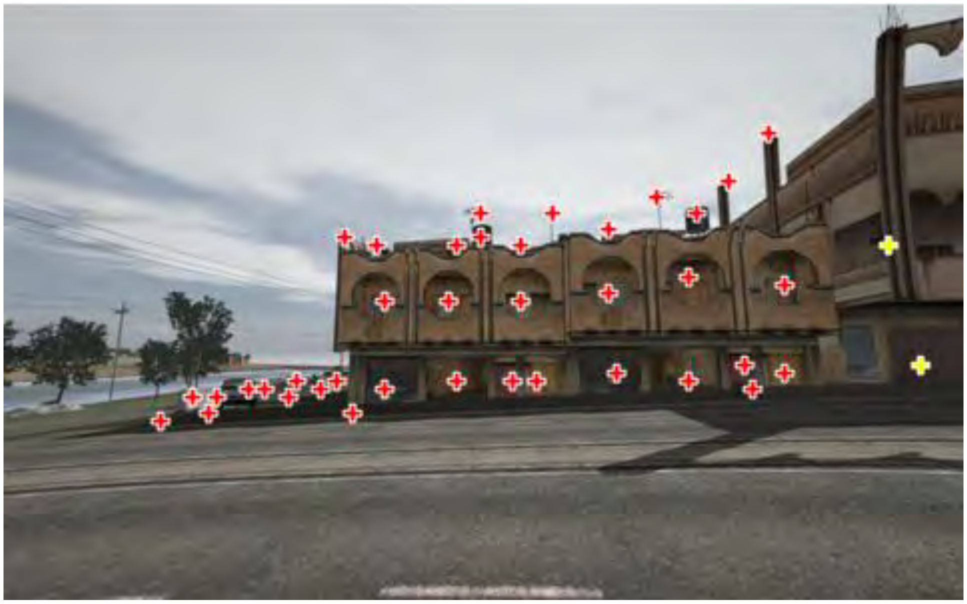

Figure 236. Scene 54, right side of vehicle, Route Red, 38 potential changes

Figure 237. Scene 55, left side of vehicle, Route Green, 25 potential changes

Figure 238. Scene 56, left side of vehicle, Route Green, 20 potential changes

Figure 239. Scene 57, left side of vehicle, Route Green, 28 potential changes

Figure 240. Scene 58, left side of vehicle, Route Green, 18 potential changes

Figure 241. Scene 59, left side of vehicle, Route Green, 27 potential changes

Figure 242. Scene 60, left side of vehicle, Route Green, 18 potential changes

Figure 243. Scene 61, left side of vehicle, Route Green, 14 potential changes

Figure 244. Scene 62, left side of vehicle, Route Green, 14 potential changes

Figure 245. Scene 63, right side of vehicle, Route Green, 64 potential changes

Figure 246. Scene 64, right side of vehicle, Route Green, 37 potential changes

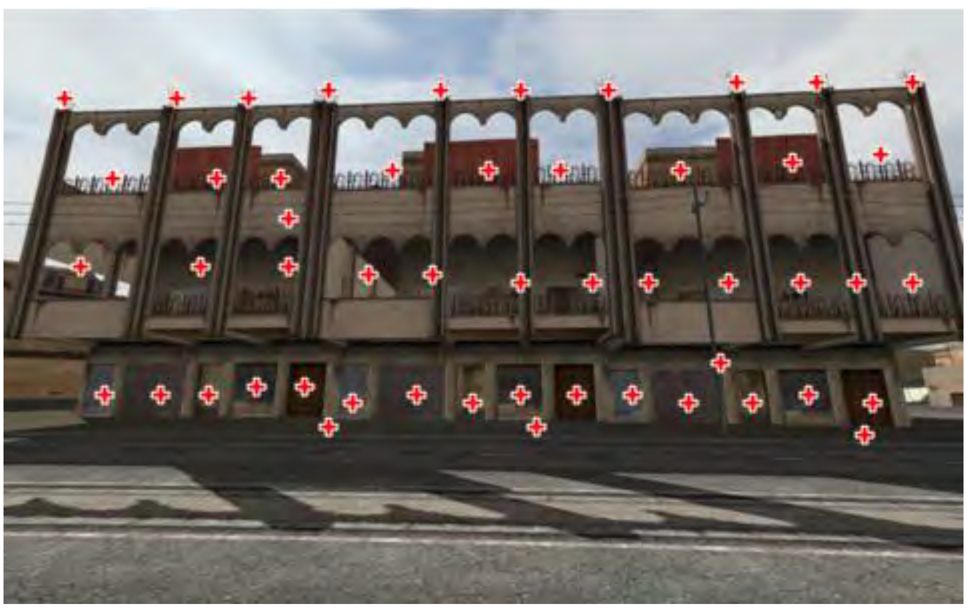

Figure 247. Scene 65, right side of vehicle, Route Green, 51 potential changes

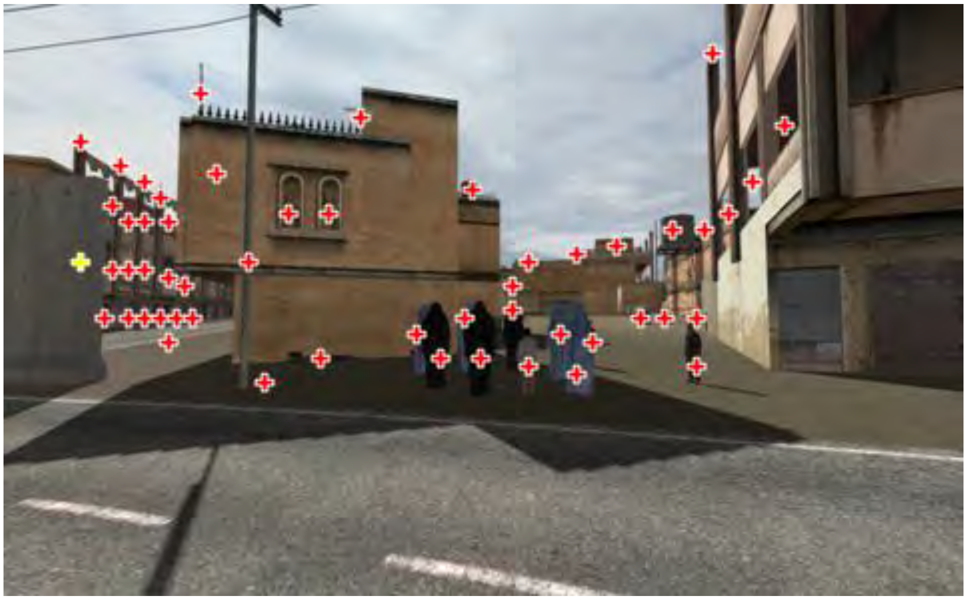

Figure 248. Scene 66, right side of vehicle, Route Green, 52 potential changes

Figure 249. Scene 67, right side of vehicle, Route Green, 48 potential changes

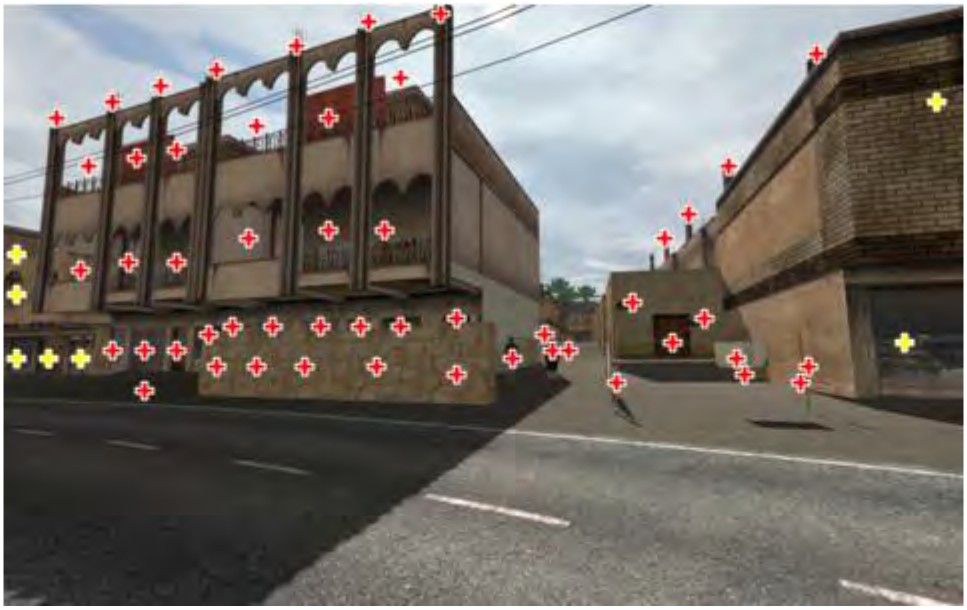

Figure 250. Scene 68, right side of vehicle, Route Green, 51 potential changes

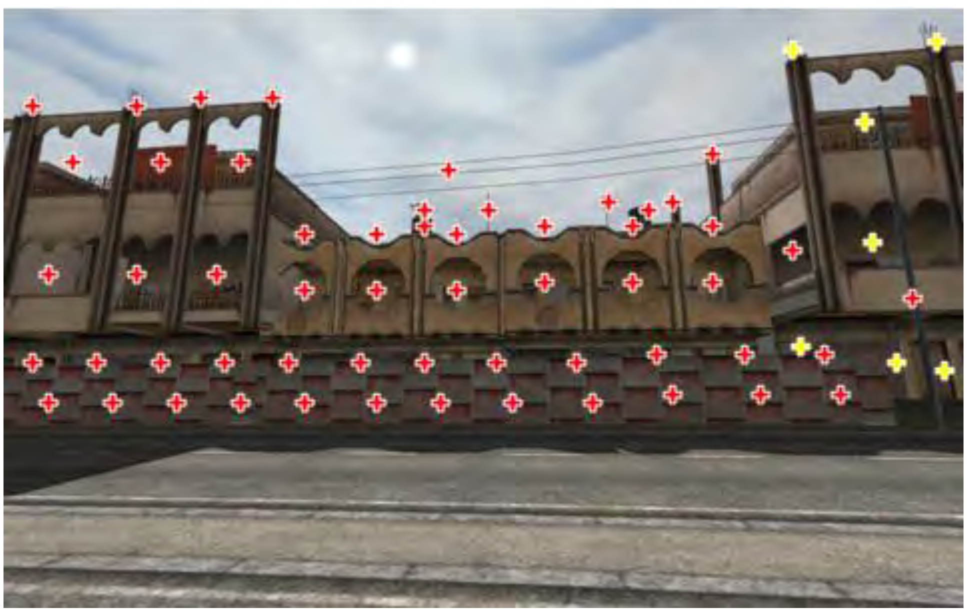

Figure 251. Scene 69, right side of vehicle, Route Green, 56 potential changes

Figure 252. Scene 70, right side of vehicle, Route Green, 89 potential changes

Figure 253. Scene 71, left side of vehicle, Route Purple, 44 potential changes

Figure 254. Scene 72, left side of vehicle, Route Purple, 45 potential changes

Figure 255. Scene 73, left side of vehicle, Route Purple, 35 potential changes

Figure 256. Scene 74, left side of vehicle, Route Purple, 45 potential changes

Figure 257. Scene 75, left side of vehicle, Route Purple, 52 potential changes

Figure 258. Scene 76, left side of vehicle, Route Purple, 20 potential changes

Figure 259. Scene 77, left side of vehicle, Route Purple, 43 potential changes

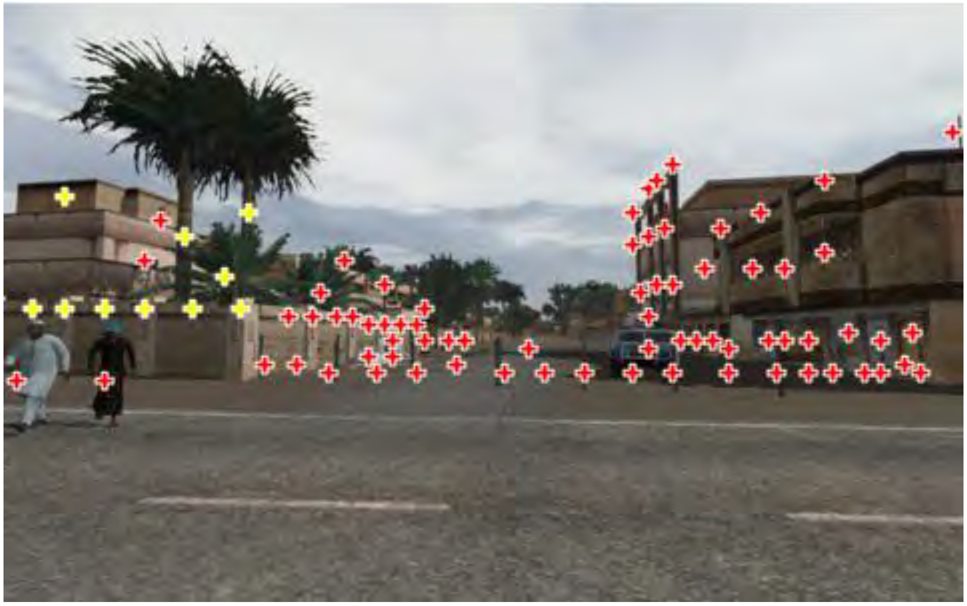

Figure 260. Scene 78, left side of vehicle, Route Purple, 70 potential changes

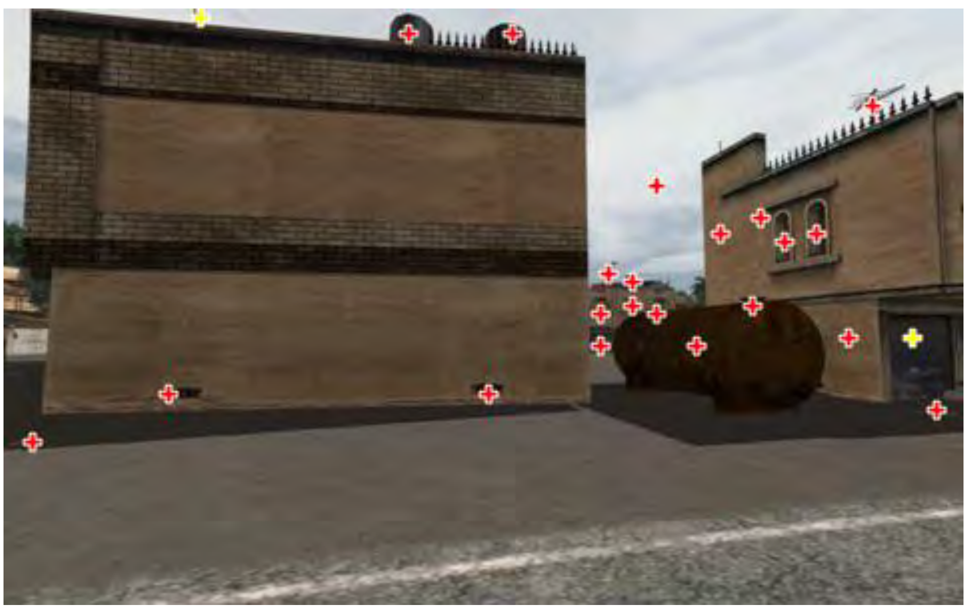

Figure 261. Scene 79, left side of vehicle, Route Purple, 21 potential changes

Figure 262. Scene 80, left side of vehicle, Route Purple, 21 potential changes

Figure 263. Scene 81, left side of vehicle, Route Purple, 22 potential changes

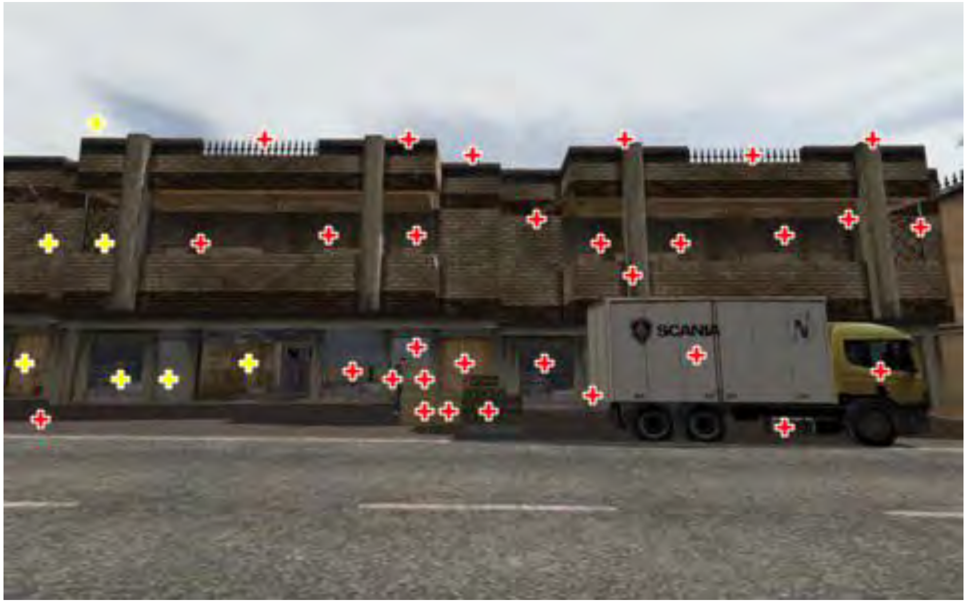

Figure 264. Scene 82, left side of vehicle, Route Purple, 30 potential changes

Figure 265. Scene 83, left side of vehicle, Route Purple, 41 potential changes

Figure 266. Scene 84, left side of vehicle, Route Purple, 66 potential changes

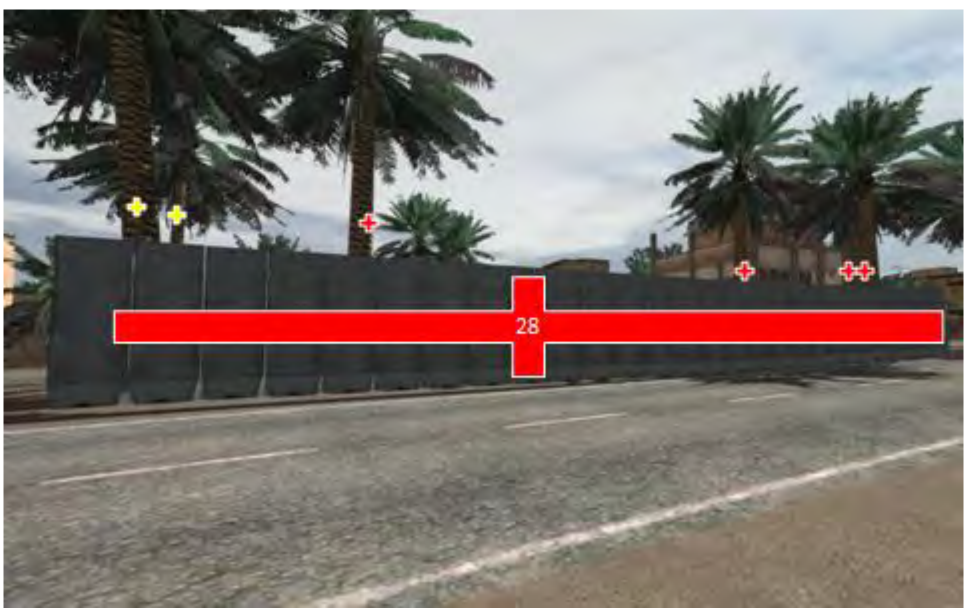

Figure 267. Scene 85, left side of vehicle, Route Purple, 32 potential changes

Figure 268. Scene 86, left side of vehicle, Route Purple, 53 potential changes

Figure 269. Scene 87, left side of vehicle, Route Purple, 34 potential changes

Figure 270. Scene 88, left side of vehicle, Route Purple, 29 potential changes

Figure 271. Scene 89, left side of vehicle, Route Purple, 29 potential changes

Figure 272. Scene 90, left side of vehicle, Route Purple, 69 potential changes

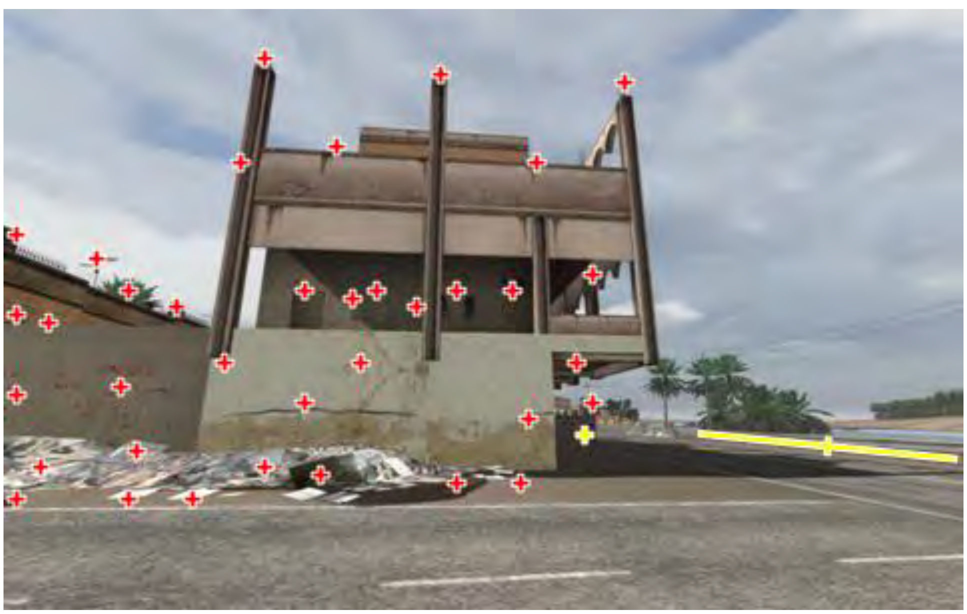

Figure 273. Scene 91, left side of vehicle, Route Purple, 37 potential changes

Figure 274. Scene 92, right side of vehicle, Route Purple, 44 potential changes

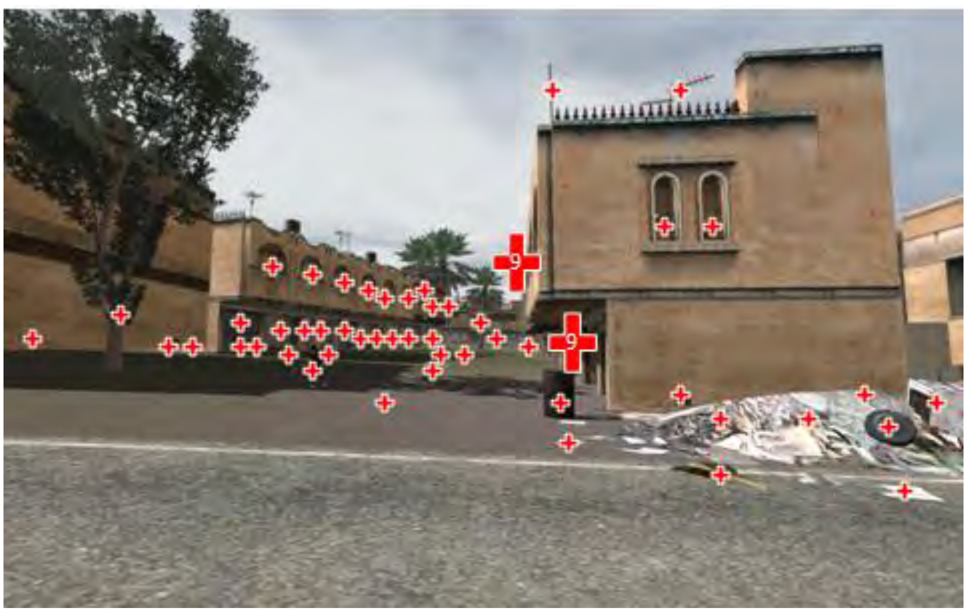

Figure 275. Scene 93, right side of vehicle, Route Purple, 67 potential changes

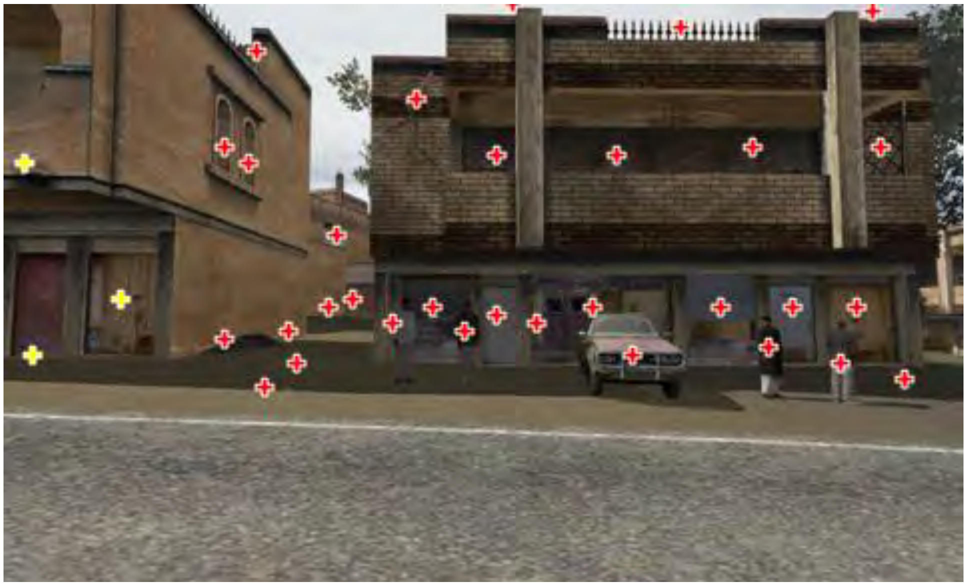

Figure 276. Scene 94, right side of vehicle, Route Purple, 32 potential changes

Figure 277. Scene 95, right side of vehicle, Route Purple, 27 potential changes

Figure 278. Scene 96, right side of vehicle, Route Purple, 45 potential changes

Figure 279. Scene 97, right side of vehicle, Route Purple, 31 potential changes

Figure 280. Scene 98, right side of vehicle, Route Purple, 41 potential changes

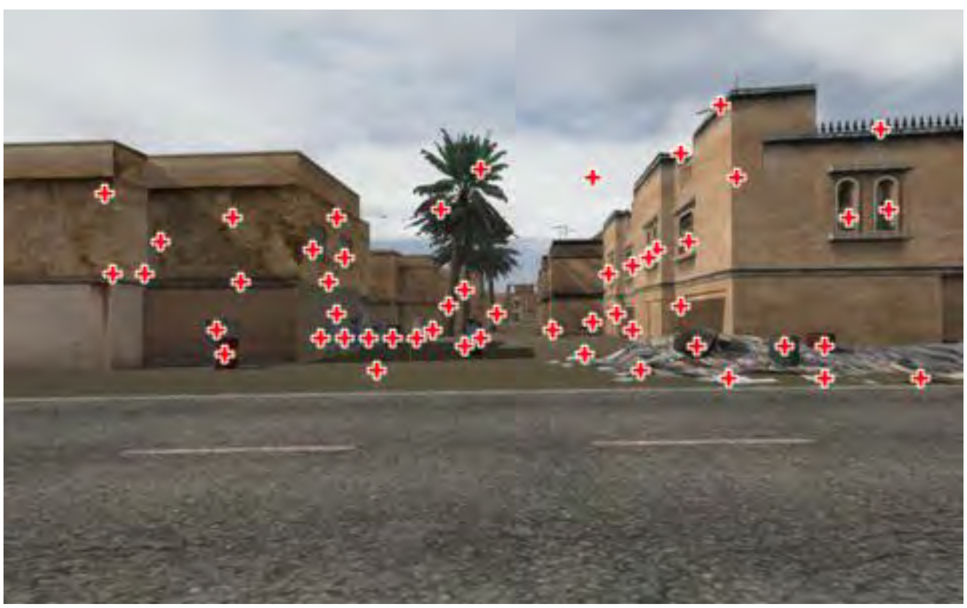

Figure 281. Scene 99, right side of vehicle, Route Purple, 54 potential changes

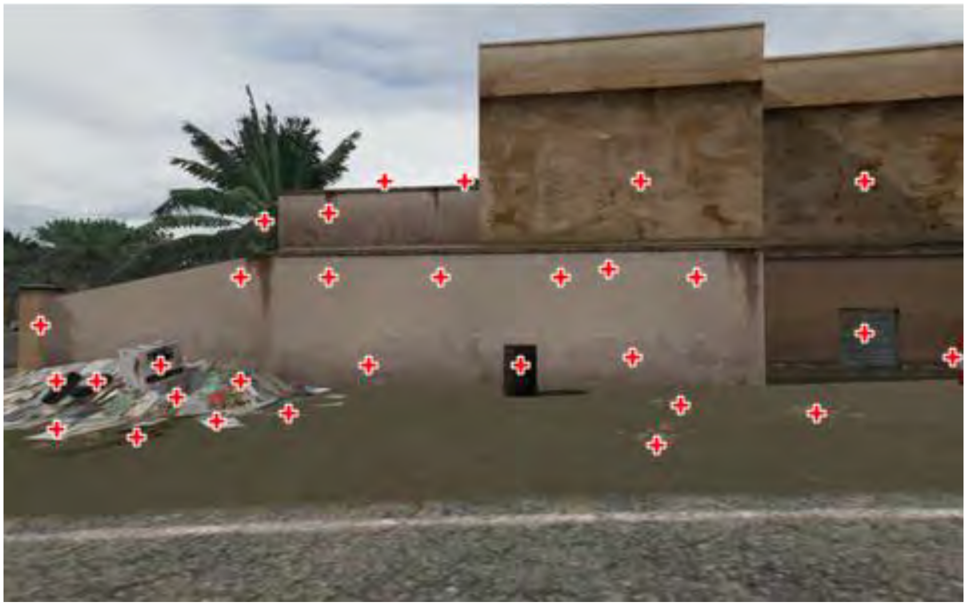

Figure 282. Scene 100, right of vehicle, Route Purple, 30 potential changes

Figure 283. Scene 101, right of vehicle, Route Purple, 61 potential changes

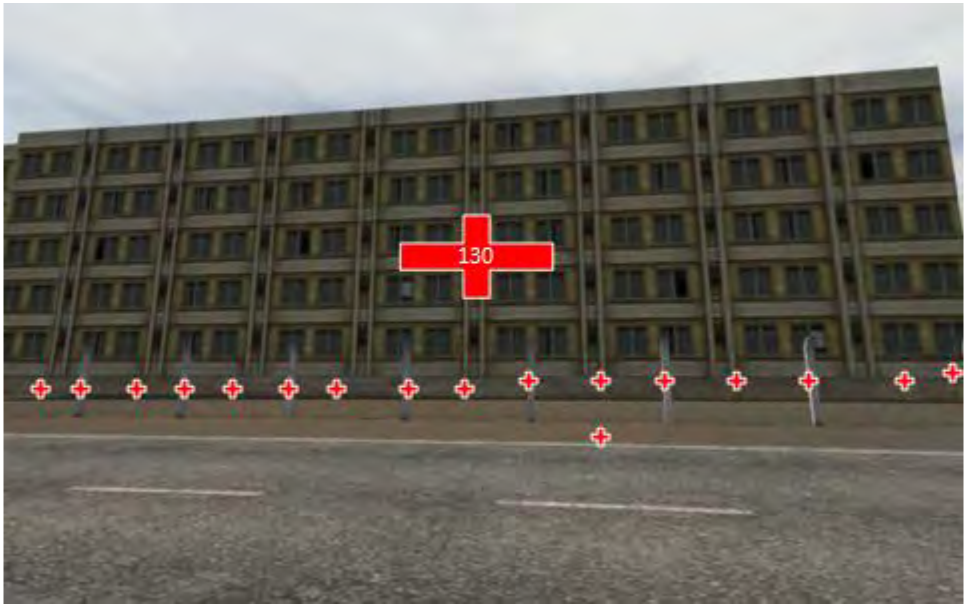

Figure 284. Scene 102, right of vehicle, Route Purple, 147 potential changes

Figure 285. Scene 103, right of vehicle, Route Purple, 154 potential changes

Figure 286. Scene 104, right of vehicle, Route Purple, 157 potential changes

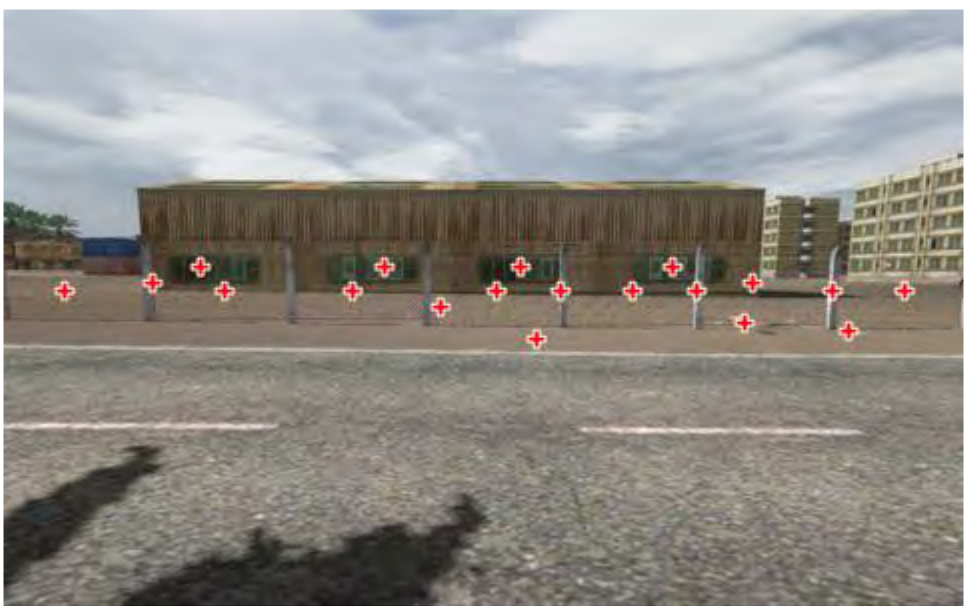

Figure 287. Scene 105, right of vehicle, Route Purple, 19 potential changes

Figure 288. Scene 106, right of vehicle, Route Purple, 23 potential changes

Figure 289. Scene 107, right of vehicle, Route Purple, 37 potential changes

Figure 290. Scene 108, right of vehicle, Route Purple, 72 potential changes

Figure 291. Scene 109, right of vehicle, Route Purple, 76 potential changes

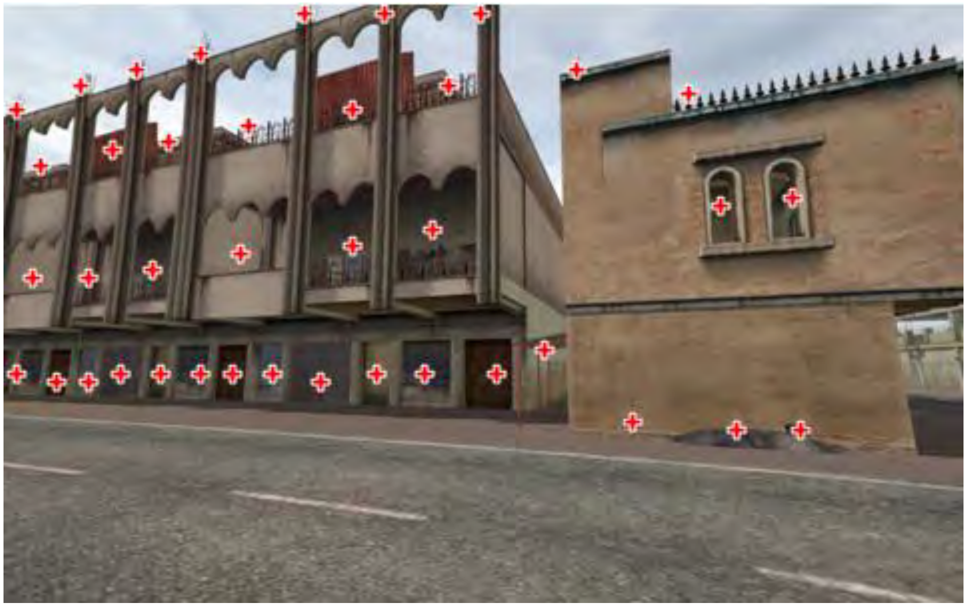

Figure 292. Scene 110, right of vehicle, Route Purple, 42 potential changes

Figure 293. Scene 111, right of vehicle, Route Purple, 29 potential changes

Figure 294. Scene 112, front of vehicle, Route Purple, 13 potential changes

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